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AN

HISTORICAL AND PRACTICAL TREATISE

UPON

ELEMENTAL LOCOMOTION,

BY MEANS OF

STEAM CARRIAGES ON COMMON ROADS:

SHOWING

THE COMMERCIAL, POLITICAL, AND MORAL ADVANTAGES; THE MEANS BY WHICH AN ELEMENTARY POWER IS OBTAINED; THE RISE, PROGRESS, AND DESCRIPTION OF STEAM CARRIAGES; THE ROADS UPON WHICH THEY MAY BE MADE TO TRAVEL; THE WAYS AND MEANS FOR THEIR GENERAL INTRODUCTION.

ILLUSTRATED BY PLATES,

AND

EMBODYING THE REPORT OF, AND ALMOST THE WHOLE EVIDENCE BEFORE, THE SELECT COMMITTEE OF THE HOUSE OF COMMONS.

WITH AN APPENDIX.

BY

ALEXANDER GORDON, CIVIL ENGINEER,

ONE OF THE WITNESSES EXAMINED.

"Next to the general influence of the seasons, upon which the regular supply of our wants, and a great proportion of our comforts so much depend, there is perhaps no circumstance more interesting to men in a civilized state than the perfection of the means of interior communication."—*Report of Committee of the House of Commons*, 1808.

"This (the steam carriage) is one of the most important improvements in the means of internal communication ever introduced."—*Report of Committee of the House of Commons*, 1831.

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& W. BLACKWOOD, EDINBURGH.

1832.

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SCHOOL OF ENGINEERING

LON

GILBERT AND RIV

ST. JOHN [illegible]

PREFACE.

In the belief, that a work upon *Elemental Locomotion*, —for the purpose of showing the utility, commercially, politically and morally, of introducing it into general practice upon the highways of the United Kingdom, and how the knowledge and practice of mechanical science had brought this desideratum within our power, —is now required for the information of society in general, I venture, after eight years spent in anxious experiment, and observation, upon this important branch of mechanical philosophy, to publish the following treatise, which pretends only to the name of a useful work; and is offered as such to the public with an earnest hope, that a subject of such vital interest may be taken up, and considered with the attention it deserves.

Mr. Nicholas Wood has so fully treated of Railroads and Locomotive Carriages thereon, that I only introduce so much of that subject as may be necessary to connect the experiments of early projectors with the happy results in later experiments; and to show the superior advantage of Steam-carriages on common roads. Without such a short account of Railway Engines a material defect would have appeared in my history of the progress of locomotion.

In Chapter I., the Commercial importance of a rapid and cheap inland communication is considered; the most obvious advantages are mentioned as concisely as possible; and the conversion of Steam to Economic purposes brought out and established by plain statistical deduction. The science of political economy, of all others the most difficult and indeterminate, finds, in the latter topic, a happy exemption from its general character: deep-rooted prejudice, and individual interests, being all that the philanthropist has here to contend with.

In Chapter II. is shown the process by which Elementary power may be converted into a substitute for animal power.

In Chapter III. such particulars are historically given of the construction of various Steam-carriages, as may afford information to engineers and others, who, from remote locality, or other circumstances, are unacquainted with the extent of improvement to which this branch of science has practically been brought.

In Chapter IV. is described the kind of Road on which Steam-carriages may be made to travel; and the loss of advantage on an inclined rail clearly exhibited.

In one or other of these Chapters I have embodied, verbatim, almost the whole of the valuable evidence of the various Witnesses examined before the Committee of the House of Commons, upon the subject I treat of. The evidence of each witness is necessarily varied in its nature, and it is quoted in smaller type, in order that as much information as possible may be concentrated at the points where most required.

In Chapter V. the very favourable Report of the said Committee is likewise reprinted, and forms a valuable testimonial to the intelligence, discrimination, and public spirit of the honourable members who formed it. In this Chapter I have also shortly considered the Ways and Means by which the conversion of Steam to the various important ends suggested can be effectually operated.

For endeavouring to open up, and call public attention to, a new path in Economical Science, admirably adapted to supplement artificially the livelihood, property, and happiness of the British Nation, and that at a moment when our natural resources have become totally inadequate for these purposes, I need make no apology. The subject has been deemed worthy of three months' close investigation by the highest and most enlightened legislature in the world. And it is a field beyond all others, of a political kind, suited to the labours of the philanthropist.

ALEXANDER GORDON,
CIVIL ENGINEER.

145, *Strand, London, April,* 1832.

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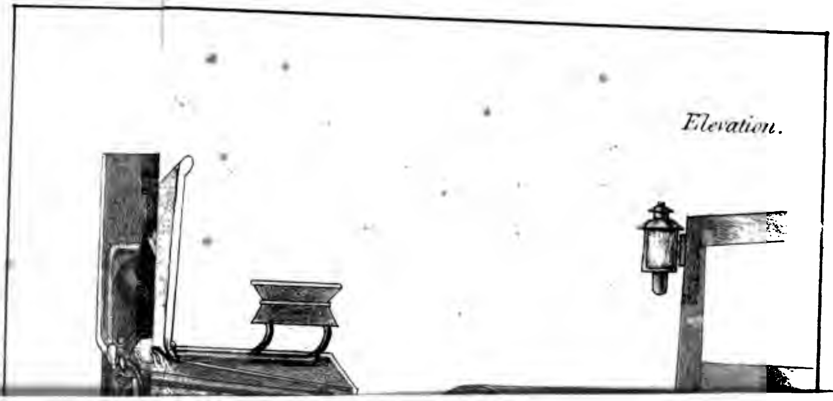
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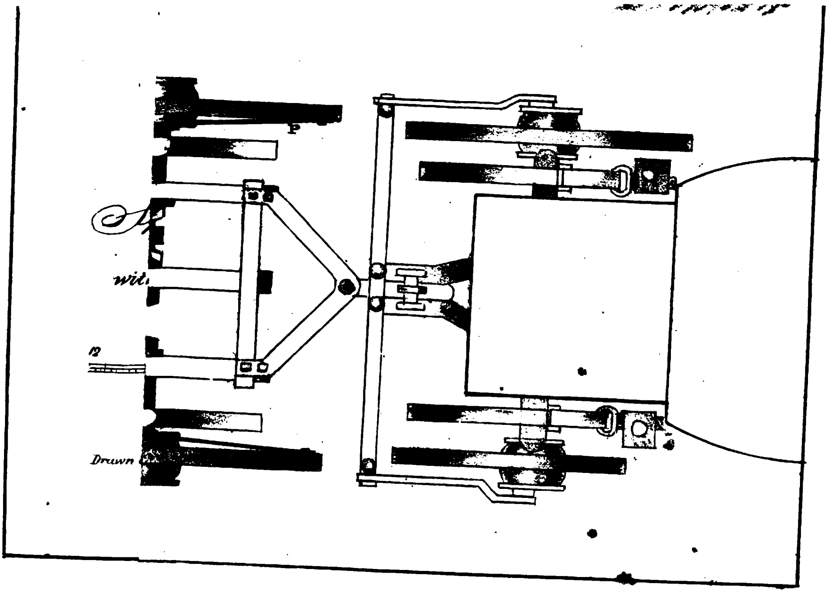
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HISTORICAL AND PRACTICAL TREATISE

UPON

ELEMENTAL LOCOMOTION.

CHAPTER I.

UPON THE ADVANTAGES OF ELEMENTAL LOCOMOTION.

In a state of society so artificial as our own, the truism—that every increase of knowledge and adaptation of scientific discovery to the wants and the exigencies of human life, tends to lessen the labour, and to increase the comfort of man, affords one of the strongest consolations and encouragements to whoever directs his attention to the amelioration of his kind. That knowledge is power, has long been a favourite and prevailing maxim, as well in mechanical as in moral philosophy. The latter we have seen realized in the rise and preservation of numerous infantine states which it has cradled into greatness. We read the former in those mighty operations which make the winds and waves obedient. That it is wealth and prosperity a long course of experience equally testifies. But it has been reserved for it in latter times to achieve, in the outgrown relations of existing society, a more extended and beneficent direction as a *political* agent. The master-mind, whose genius called up into operation that mighty power, the discovery of which in mechanics, in an age of inventions, stands out with as pre-eminent distinctness in the nineteenth as the discovery of a new world illustrates the fifteenth century, perhaps did not, in revolving all its varied and wonderful properties of scientific application—contemplate it in its highest result of all, the possibility, namely, of its conversion to *Economic* purposes, sufficient to uphold and perpetuate the prosperity and happiness of the British Empire to a period of almost indefinite duration.

At a crisis like the present, when the country is labouring under the pressure of a redundant and starving population, the subject which we are about to treat upon comes recommended with a peculiar emphasis. The substitution of an inanimate for an animate power, by which an increase of food equivalent to the consumption of sixteen millions of mouths—which is equal to the addition of a territory double in extent to that of Ireland—possessing all its natural resources and fertility, without the drawbacks of an unmanageable population, is a project, which bears on its surface, not the interests of a handful of individuals—a class of society—or branch of trade—but of the whole nation. How fortunate then is it, that it further comes with the recommendation, of not presenting itself in the doubtful guise of an expedient speculative question—but as a plain, practical, demonstrable matter of fact, realizable in operation, and determinate in result. This will appear in obvious sequence from the unvarnished facts which we now, in detail, proceed to adduce as proofs and illustrations of the truth of our position.

In a great complex question of this kind, involved, not in theory but in what is equally disadvantageous, the suspicion and doubtfulness of a novel project,—where all the results lie so far beyond the ken of a bird's-eye estimate,—which is to trench in so many respects upon the selfish relations of "slaughter-house" capitalists,—and is to equalize the permanent prosperity of the multitude to the temporary inconvenience of the few,—it must ever be borne in mind, that to whatever point of detail we direct our attention, we shall perceive but a very limited view of the benefit, as a whole, which is to arise from the introduction of this grand agent, when it shall be properly economised, and brought to bear in full operation upon the varied transactions of daily life. We shall therefore confine ourselves to a cursory estimate of a few of the leading *Commercial*, *Political*, and *Moral* advantages which will accrue to the community by the substitution of inanimate or steam-power for animate or horse-power, for locomotive purposes: leaving it to the enterprising and reflective to revolve the mighty amount of practical good which it may be made to subserve, if taken up, as it ought, as a national measure.

In a great commercial country like ours, extending its ramifications to every branch of natural and artificial produce, it is almost superfluous to remark that a vast capital is sunk annually in the mere transport of marketable commodities: and which is not only a loss to the seller as being an unproductive outlay, but entails a heavy increase of expense to the buyer also upon every article of daily consumption. Any means, therefore, that will accelerate the conveyance, and at the same time reduce materially the expense of carriage, bears upon its surface a great public gain.

Expeditious locomotion, to the commercial world more particularly, in every mercantile transaction, is equivalent to capital: and such is the vast importance of economy of time here, that no extra expense is considered as too great to accomplish the utmost speeds. We have this practically illustrated in the preference which society gives to a complicated machinery put into motion at an enormous expense, to travelling by the winds of heaven which cost nothing. Nay, we have lately seen the speed of eight miles increased to nine, though purchased at an addition of *one-third* of the original outlay; and that again accelerated to ten, though it could only be effected by *doubling* the whole cost!

To the merchant time gained is equal to money: for time occupied in travelling is just so much profitable employment lost. Time occupied in the transport of goods is equivalent to so much interest of capital spent: for a thousand pounds invested in merchandise is unproductive so many days as the transport is tedious. That part of the capital of an individual which is employed in the carrying of his goods to and from market, is so much abstracted from his means of producing more of the article in which he exerts his ingenuity and labour, whether it be in agriculture or manufacture.

Easy communication lessens the time occupied in the transport; and a saving of time lessens the distance, or our notion of distance[1]. This effects a saving of money; and a saving of money

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[1] The Liverpool and Manchester rail-road Co. lately reported this result:—

Passengers entered in the Company's books during the half-year ending 30th June	188,726
Ditto, ditto, ending 31st December last	256,321
Increase	67,595

Being upwards of 33 per cent. increase of the first six months of the year, and upwards of 135 per cent. increase on the travellers between the two towns during the corresponding months previously to opening the railway.

permits of a greater employment of capital. The man who can only afford to keep one traveller soliciting orders for his goods, will thus be enabled to keep two; because the expense of travelling will be reduced a half. Or it may be, he will find it more advantageous to employ the saving in the production of a more delicate and desirable article in the way of his trade. The increased traffic from place to place will give likewise an impulse to business, which, in the present stagnant times, is most desirable. The manufacturer in Scotland will find the London market more easily arrived at; and the merchant in the metropolis will be able to get his orders more rapidly given and executed. A conveyance which, in good management, would be a weekly one, is, in bad management, a monthly one: and the carrier is obliged to quadruple his charge for the transport. To meet this charge the merchant has to add to the cost of the article, and so on throughout the various gradations of mercantile transition, until the consumer pays the necessarily increased price. Hence, whatever reduces the price of transportation, reduces the price of the commodity transported. Whatever reduces the traveller's time, reduces his claim for compensation, and (competition being always at work) he is content with a smaller profit upon his merchandise. If a scarcity of any article occurs at one point of the kingdom, the monopolist there cannot continue his increased price for any duration of time. Commerce may, in this respect, be resembled to water, for, if not obstructed, it will always circulate till it finds its level. An opening or channel being furnished, an equalised supply will make its way wherever required.

Thus we see that the strength, wealth, and happiness of a nation, depend very much upon facility of communication. The ill-defended spot in the empire is alive to the reality, that subsidies having bad roads or a tedious navigation to pass may arrive too late to present an effectual resistance to a plundering enemy. The hard-working emigrant of a remote settlement, distant from a market, feels the difficulty and loss he sustains in bringing produce to the spot where merchants and dealers meet for the purposes of exchange. A spot uncommunicated with may be visited by the horrors of famine, and no channel exist for conveying thither the food required. A grievous pestilence may sweep off an isolated people before the aid of the physician can arrive to arrest its progress.

Such facts are obvious to even the most indifferent observers of human society. Yet, nevertheless, there have been, and are, short-sighted individuals, in every gradation of it, with minds and views so warped and distorted by an ignorant selfishness, that they have opposed every improvement which tended to make the least change in their long-established habits. Such persons were they, who, during the last century, promoted petitions from counties in the neighbourhood of London, praying Parliament not to extend the turnpike-roads into remoter parts of the country, lest these remote districts, by means of a less expensive labour, should be able to sell their agricultural products in the London markets at a cheaper rate than themselves! —and such in our own day are the attempts made to put down steam conveyance. How short-sighted we are! Did we consult our own advantage we should see that those facilities of communication, against which we oppose ourselves, are the growing sinews of a greater fabric of wealth and prosperity.

Such are the numerous and important advantages, in a Commercial point of view, which will result to society from the substitution of elementary for physical power. But even these, great though they be, are of trifling consideration when compared with the immense benefits which will result from the substitution when brought into operation as an Economic principle.

In entering upon a statement to show the practicability of turning steam to this latter and novel purpose, we are relieved by the investigations of another branch of philosophy, from the necessity of going into detail to show the *utility* of that conversion: political economists, after maturely investigating the complex causes of national poverty and distress, having come to the conclusion, that the grand source of all our evils is *redundancy* of population; or in other words, an increase of animated life *beyond* the nourishment adequate to support it.

Perhaps we should qualify the term beyond—because, literally speaking, population cannot exist *beyond* the means of subsistence, but *only up* to it. There is a limit to increase: " a principle in society," according to Godwin, "by which population is perpetually kept down to the level of the means of subsistence." That principle is *want of food;* the prolific parent of pauperism, unemployment, starvation, vice, disease, wretchedness, and their attendant evil train. There are, to be sure, other restrictive assistants, but this is the available one:—the grand retarder and arch enemy of our species. To live, then, *up* to the limit of food, entails upon us the host of ills just enumerated:—to live *beyond* the limit, precipitates us swiftly into famine, pestilence, and death.

But though political economists are at one as to the disease, there has been great discrepancy of opinions as to the remedy. Colonization—emigration—equality of condition—moral restraints—community of labour and of goods—reclaiming of waste lands—artificial restrictions upon fecundity, &c. have all afforded ample themes upon which the projector or philanthropist have erected the unsubstantial structures of their respective systems;—all beautiful as ideal theories, but all worthless in practice; because partial, temporary, or impracticable,—not applicable to the real condition, or realizable for the improvement of man.

The substitution of inanimate for animate power, if not the panacea which is to cure all the evils of our condition, is at least one that comes recommended as a matter of fact—easy of operation, and effectual in its result. If want of food, or, in other words, redundancy of population, be the bane of the country, it does not propose to meet that evil by a visionary project, tending in its operation to unhinge society,—tedious in its process, and ending at length in bitter disappointment—but it meets the evil directly, substantially, and effectually, by the substitution of food. It does not raise a cry of *bread, bread*, and then conclude by giving a *serpent;* but by the application of elementary for physical power, it creates an economic principle, such as philanthropists never dreamed of; which, if not the feigned philosopher's stone, to convert all that it touches into gold, is a power in nature equally beneficent, since, besides its being real, it can change poverty into comparative affluence—starvation into subsistence—disease into health—misery into comfort, and vice into virtue.

And how are all these immense advantages to be effected?—By the substitution of inanimate for animate power. At present, the animate power employed in the commercial transportations of this great kingdom is estimated to amount to two millions of horses: each horse consumes as much food as is necessary for the support of eight men. Hence the conversion of its consumption to purposes of human existence would, if carried to this practical extent, amount to a quantity of food equal to support sixteen millions of people.

Where the product is so enormous—so vastly beyond our immediate necessities—it is not requisite to go into any minutiæ of detail. To calculate all the gains we will leave to the political economist, as also to bring the matter out in its fair proportions; but to establish the matter clearly within the bounds of a safe, an easy, and practical issue, we have merely to state, that a conversion of food from a physical to a moral purpose, adequate to the supply of one-fourth part of the above aggregate estimate, that is to say, to four millions, is amply sufficient to relieve us at the present moment from that pressure of pauperism which sits like an incubus upon the energies of the nation, and which will precipitate us, if not timely avoided, into speedy and irretrievable ruin.

Now the suppression of the stage-horses upon our principal thoroughfares, and of the dray-horses in the great commercial towns, may be calculated to economise a saving of food equivalent to the supply of the above number of human beings.

It is, perhaps, not superfluous to remark, that the amount of food, equal to the supply of the said four millions, is not the produce of an extended agriculture and proportionate outlay, but is just *that part* of the annual produce of the country, subtracted from the whole, which is at present required for the mere purpose of *transportation*—i. e. to feed the animals used for draught,—and is consequently a dead loss as unproductive capital.

In addition to the evil arising from such a consumption of unproductive food, is also to be considered the very great loss consequent upon the heavy capital sunk in *horse* purchase. Were this viewed, as properly it ought, as money withheld from other purposes of trade, and which might be more advantageously invested, our capitalists and men of science would not oppose the substitution of inanimate for animate power in the way they have done. Neither, did the landed interest maturely weigh the varied benefits it will produce in agriculture, would they view it in the light of an invasion upon their respective interests. They do not give a *quid* without receiving a *quo* every way as valuable. The reduction of farm consumption—the bugbear of the project—will be met and compensated by a steady and proportionate demand from other quarters. Whilst in the United Kingdom, the 8,100,000 acres of land now required to feed the horses, together with the capital sunk in their purchase, will, when both applied to other and general purposes, amply compensate for the exchange.

In order more readily to show one effect, let the horses be considered only 1000; a smaller number may not make the argument so difficult. Let us reduce *this* number[1], and the farmer may then turn his oat-ground into wheat-ground; and instead of so much land being employed to furnish food for a thousand horses, the same land, when turned into tillage fit to sow wheat upon, will produce sufficient bread-corn to feed two thousand poor families.

Again, if instead of 20,000 horses, we keep 30,000 fat oxen, butchers' meat will be always cheap to the operative classes, whilst the quantity of tallow will of course make candles cheap: and so many hides lower the price of leather, and of shoes and all other articles made of leather. Or the same quantity of land may then keep thirty thousand cows, the milk of which will make both butter and cheese cheaper to the poor, as well as the labouring manufacturer; all which articles are very considerable, and of material moment in the prices of our manufacturers, as they, in a great measure, work their trade to rise and fall in price, according to the cheapness of their materials and the necessaries of life. The same may be said in favour of more sheep and woollen cloths.

We have said, a horse consumes, on an average, as much as eight human beings. The country is burdened with poor (in want of food); so much so, that an evil is resorted to, to ease the burden; and the strongest and ablest of our peasantry are encouraged to emigrate. Our political strength is thus wasted, while the prospect that eventually these very men may meet us in battle array is avoided in our search for present ease. Whilst, therefore, we have a remedy really good and practicable before us unresorted to, we may in truth say that we depopulate our country for a "bestial herd."

But it would be taking but a limited view of this part of our subject did we confine ourselves to the above observations, important though they are: there are great *financial* results to be considered likewise. The experience of the last thirty years has shown that we have hitherto legislated in vain for Ireland. A starving population cannot be cured either by education on the one hand, or by coercion on the other. Laws, however judicious in themselves, or beneficently administered, must fail to accomplish their purpose amongst a redundant impoverished people. It is bread they want: and this deficit has been the *fructifying* source hitherto of the disordered structure both of her political and moral condition. But let us, by the introduction of inanimate power, supply this want, and we do not, like Mr. Canning, create a transatlantic kingdom, but we resuscitate one at home, leagued to us by blood, by union, and neighbourhood. Let us *make them food*, and they will make themselves educated, and industrious, and happy, and prosperous. The yoke removed which has hitherto bowed the neck of the finest race in the world, Ireland will rise up, though late in time, in the energies of a renewed people to add a vast fund of financial support, instead of the heavy burden she has hitherto been, to England. And if the last of the Union to attain her meridian of greatness and prosperity, she will likewise be the last to hand down the greatness and prosperity of the British empire to future times.

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[1] It is worthy of remark, that when private carriages became common in this country, an act was passed to prevent the too great adoption of these vehicles, *lest the horses should consume the food of the poor.*

Nor will Scotland find less advantage from a change which will enable her to command a distant market for her home commodities; and which, at the same time, will bring all her imports cheaper to her doors. The produce of her mines will become more valuable, and property acquire a worth which hitherto it has not attained—the increase of finance returns will of course be proportionate.

In various departments of the revenue the saving of expenditure by the substitution of inanimate for animate power will also be immense. In the post-office alone, for instance, it will amount to upwards of half a million. Whilst, from the cheapness of food which the substitution will produce, the navy and army estimates will be most essentially reduced.

The corn-laws are another evil which the adoption of this great measure will completely extinguish—not indeed by their repeal, but by what is much better, the necessity for their repeal no longer existing.

Nor will corn alone become cheap and abundant, but all the necessaries of life will comparatively become equalized. No longer will local failures of crop expose remote districts to temporary visitations of famine and disease: but steam introduced will circulate the produce of the land in liberal profusion. Then the pilchards of the Channel will no longer be used to manure the bordering counties, when they can be eat *callar* throughout the North: nor will the inexhaustless shoals of the herring depart untithed from Loch Fine, because no inland consumption holds out a bonus for their capture.

It is not difficult to perceive how all these important results will enable the country to meet and liquidate the national debt. The payment of the taxes, under a system where pauperism and redundancy will be alike unknown, will no longer be a burden; whilst the vast savings which will accumulate in consequence in every part of the revenue will speedily form a sinking-fund, under which even our enormous debt will eventually disappear.

Having thus, we hope, made the importance of this measure in some degree plain, both as a matter of utility and policy—we have to meet one or two objections.

It will be argued that an increase of food, or subsistence, will *increase* our population, and eventually precipitate us into worse calamities than what it for the present remedies. No doubt our population will increase; for increase and prosperity are terms that are relative. But what then? if we can relieve many generations from the consequence of reaching the limit, (i. e. of poverty, vice, misery, and disease,) are we to avoid doing so because society will grow progressively till it again meets the limit? We trow not: as sensible were it never to eat when hungry, because we shall again be hungry! Our business is to postpone the evil day, and to allow subsequent generations to economize for themselves. Is it reason, or humanity, or interest, or duty, to avoid getting rid of the fearful crisis of national misery that is setting in upon us, because we are met with the hypothetical supposition, that a similar crisis may be the lot of our descendants one hundred and fifty years hence? No, not to avoid the crisis is to perpetrate a national *felo de se*, at the expense of all the moral obligations which man owes to God, himself, his neighbour, and society.

Another argument against the substitution of inanimate for animate power will be raised by the agricultural interest, who will see in this conversion of food the fall of all agricultural produce. This also we admit—but we contend that they do not sustain a loss without an equivalent. The sum which is expended in horse consumption is an unproductive capital, which finds remuneration in a per centage upon every transportable commodity. But when these commodities can be transported for a nominal value, a proportionate reduction will take place upon the price of the commodities themselves. Hence the farmer will sell his farm-produce cheaper—but at the same time he will purchase his commodities cheaper: and the one will balance the other. His loss in grain will be a gain in all the transported necessaries of life. If his income be reduced, his expenditure will be reduced proportionably. Hence the change is in terms, not in reality.

We do not advocate any thing so preposterous as the change of the whole animate power of Great Britain into inanimate, though in this the political economist can see the solution of all our Malthusian difficulties to an indefinite extent and duration. What we urge is merely the partial adoption of the thing to such an extent as will relax the present pressure, and restore us to a wholesome state of national prosperity. This will occasion no dangerous experiment, and will be gradually followed up by a progressive conversion, by which all the conflicting interests of society will be neutralized, and the aggregate wealth, and prosperity, and happiness of the empire be equalized.

If then *elemental locomotion* can be made to substitute the expensive, unproductive system of animate labour now in use, it will indubitably be for the vital interest of all classes of society that the substitution should be realized speedily and extensively. That steam can be so applied has, as will afterwards be shown, been *satisfactorily proved.* The report of the Committee of the House of Commons, which will be found in a subsequent chapter, establishes this. But the evidence of several of the enlightened and practical witnesses who were examined before that committee bears with too much emphasis upon the detail of the commercial and economic advantages of the project we have just been attempting to enumerate and advocate, for us not to avail ourselves of it even at this early stage of our work. It being quite decisive in support of the grand conclusion to which the said committee came after three months of patient and thorough investigation of the subject, viz. "*That the substitution of inanimate for animate power is one of the most important improvements in the means of internal communication ever introduced.*"

We have said in our preface, that the official evidence taken upon the subject of steam-carriages, before the Select Committee of the House of Commons, during the autumn of 1831, should be adduced in support of our views. This Committee, in consequence of the heavy tolls imposed upon vehicles propelled by steam or gas, was, at the petition of Mr. Gurney, appointed to sit, and continued for three months a deliberate investigation. And their report, with the evidence, was ordered by the House to be printed.

The evidence of Colonel Torrens, M.P. before that Committee (see Report, page 104) was as follows:

" Have you considered the effect which will be produced upon British agriculture, by substituting, on common roads, steam-carriages for carriages drawn by horses ?"—" I have."

" What do you conceive that effect would be ?"—" I think it would produce very beneficial effects upon agriculture."

" State your reasons for believing that agriculture will be benefited by substituting inanimate for animal power, consuming the produce of the soil ?" —" I conceive that agriculture is prosperous in proportion as the quantity of produce brought to market exceeds the quantity expended in bringing it there. If steam-carriages be employed instead of carriages drawn by horses, it will be because that mode of conveyance is found the cheapest. Cheapening the carriage of the produce of the soil must necessarily diminish the quantity of produce expended in bringing a given quantity to market, and will therefore increase the net surplus, which net surplus constitutes the encouragement to agriculture. For example, if it requires the expenditure of two hundred quarters of corn to raise four hundred, and the expenditure of one hundred more on carriage, to bring the four hundred to market, then the net surplus will be one hundred. If, by the substitution of steam-carriages, you can bring the same quantity to market, with an expenditure of fifty quarters, then your net surplus is increased from one hundred to one hundred and fifty quarters; and, consequently, either the farmer's profit or the landlord's rent increased in a corresponding proportion. There are many tracts of land which cannot now be cultivated, because the quantity of produce expended in cultivation and in carriage exceeds the quantity which that expenditure would bring to market. But if you diminish the quantity expended in bringing a given quantity to market, then you may obtain a net surplus produce from such inferior soils, and consequently allow cultivation to be extended over tracts which could not otherwise be tilled.

" On the same principle, lowering the expense of carriage would enable you to apply additional quantities of labour and capital to all the soils already under cultivation. But it is not necessary to go into any illustrative examples to explain this, it being a well-known principle, that every improvement which allows us to cultivate land of a quality which could not previously be cultivated also enables us to cultivate, in a higher manner, lands already under tillage."

"If horses were displaced from common roads, would not the demand for oats, beans, and for pasture, be diminished, and land thereby be thrown out of cultivation, and labour out of employment?"—"If steam-carriages were very suddenly brought into use, and horses thereby displaced, I think the effect stated in the question would be produced for a time; but, practically, steam-carriages can be introduced only very gradually, and the beneficial effect upon the profits of trade, by bringing agricultural produce more cheaply to market, will tend to increase profits, to encourage industry, and to enlarge the demand for labour; so that by this gradual process, there will probably be no period during which any land can actually be thrown out of cultivation, the increasing population requiring all the food which horses would cease to consume. With respect to the demand for labour, that demand consists of the quantity of food and raw materials which can be cheaply obtained; and as, by the supposition, the displacing of horses will leave at liberty more food, and more material, the demand for labour will ultimately be greatly increased, instead of being diminished. It has been supposed, I know not how accurately, that there are employed on the common roads in Great Britain[1] one million of horses, and a horse, it is calculated, consumes the food of eight men. If steam-carriages could ultimately be brought to such perfection as entirely to supersede draught-horses on the common roads, there would be food and demand for eight millions of persons. But when we take further into consideration, that lowering the expense of carriage would enable us to extend cultivation over soils which cannot now be profitably tilled, and would have the further effect of enabling us to apply, with a profit, additional portions of labour and capital to the soils already under tillage, I think it not unfair to conclude, that were elementary power on the common roads completely to supersede draught-horses, the population, wealth, and power of Great Britain would at least be doubled."

"There are soils which are stated to be so poor, that oats alone can be raised upon them; would not the substitution of steam for horse-power have the effect of throwing out of employment the labour required for the cultivation of such lands?"—"If there are soils of such a peculiar quality that oats is the only marketable product which they will yield, the persons employed in cultivating those lands would certainly be thrown out of that particular occupation; but the extension of tillage over other lands not of this peculiar quality would create a demand for labour which would much more than absorb the persons thrown out from the culture of oats upon that land which would grow nothing else. But I doubt of there being any land which it is profitable to cultivate which would not raise some other agricultural produce than oats, either for man or cattle, for which the increasing population would create a demand."

"The general impression on the minds of the committee is, that steam-carriages will, at least for the present, rather be substituted for horses used in conveying travellers than for the conveyance of bulky articles. Do you think that the substitution of steam in this manner will be injurious to agriculture and to the demand for labour, without any adequate compensating advantages?"—"Upon the case supposed, namely, that steam-carriages should be employed in conveying passengers only, and the whole change to be effected in a sudden manner, I think that there would in the first instance be a diminished demand for agricultural produce, but the following process would take place. As the demand for agricultural produce was diminished, the price of such produce would fall, food would become cheaper, and the cheapening of food would benefit partly the labouring class and partly the capitalists, the one obtaining higher real wages, and the other higher profits; this increase in real wages and in profits would effect a great encouragement to manufacturing industry, and would necessarily lead to an increase in the manufacturing population, and to the amount of capital employed in manufactures. The consequence would be, that after some degree of pressure upon agriculture, the increased number of human beings would create the same demand for agricultural produce which the employment of horses formerly created. So that even upon the extreme and most improbable supposition, that steam-carriages should never be employed in conveying agricultural produce to market at a cheaper rate, still the benefit to the country would be very great, inasmuch as we should have a vastly increased industrious population, and England would become much more extensively than she is at present the great workshop of the world. In point of fact, superseding horses by mechanical power would have precisely the same effect in increasing the population and wealth of England, as would be produced were we to increase the extent of the country by adding thereto a new and fertile territory, equal in extent to all the land which now breeds and feeds all the horses employed upon common roads. Such addition to the extent of fertile territory in England, suddenly effected, would in the first instance lower the value of agricultural produce, and be injurious to the proprietors of the old portion of the territory; but no person would therefore contend, that if we could enlarge the Island of Great Britain, by additional tracts of fertile land, the public interests would be injured by such enlargement: this would be monstrously absurd. It is not less absurd to object to the increase of food available for human beings, by substituting mechanical power for horses."

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[1] This is not including horses used for draught in agriculture ploughing. In the former pages, I include these, and all horses but horses of pleasure.

"In addition to the advantages you have already anticipated from the introduction of steam-conveyance, would not the increased speed and cheapness of intercourse occasion vast public benefits, in which agricultural capitalists and labourers must greatly partake?"—"Certainly."

"As it is impossible to conceive that steam should be generally substituted for horses, and be confined only to the conveyance of travellers; and as it would necessarily be employed as vans and coaches are at present, for the speedy conveyance of light goods as well as travellers, (by the hypothesis, steam-carriages being cheaper than horse-draft, or it would not be used), would not such cheapening of the conveyance of such goods have a considerable effect upon the demand for them, and thereby for labour and food?"—"On the principles that have been already stated with respect to agriculture, the cost of bringing all things to market is comprised of the cost of production and the cost of carriage. Reducing the cost of carriage is precisely the same thing in its effects as reducing the immediate cost of production; consequently, the conveyance of light goods by steam power must cheapen all such goods to the consumers. This will necessarily enable them to consume a greater quantity of such goods; and the consumption of the greater quantity will enlarge the demand for labour, call a larger manufacturing population into existence, and thereby re-act on agriculture by increasing the demand for food. This cheaper mode of internal carriage will not only lower the price of light and refined manufactures to the home consumer, but will lower their price also to the foreign consumer. This will increase the advantages which we at present possess in the foreign market, and tend to increase our foreign commerce. So that here again there will be an increased demand for manufactures and for a manufacturing population, and here again will be another beneficial re-action upon the soil. So that the more we contemplate the various effects produced upon the industry of the country by a cheaper mode of conveyance, the more we must be convinced that wealth and population will be increased, and that agriculture, instead of being injured, mnst necessarily partake in the increased prosperity of the country. In addition to what I have already stated, the saving of expense and of time in conveying passengers and goods, and the rapidity of communication, will produce effects, the amount of which it would be almost impossible to calculate.

The evidence of Mr. John Farey, engineer, (Report, p. 54), is as follows:—

"Steam power will propel a carriage as cheaply at a quick rate as at a slower rate; that fact is proved on railways, in actual business: and steam-coaches will be the same whenever they can be made strong enough to bear quick motion without being overloaded with weight of machinery. That will be one of their great advantages over horse labour, which becomes more and more expensive as the speed is increased. There is every reason to expect, that in the end the rate of travelling by steam will be much quicker than the utmost speed of travelling by horses; in short, that safety to travellers will become the limit to speed, as is now the case on railways."

"What is your opinion as to impelling waggons by steam?"—"I have never considered that at all in detail, and am not prepared to give evidence upon the subject. The price of carrying passengers or goods at a quick speed, as is done by stage-coaches or vans, will always be so much higher than the prices of carrying an equal weight at a slow speed, as is done by waggons, that I see no inducement to attempt steam-waggons, which I think would present almost all the same difficulties as steam vans. According to theory, the cost of carriage by steam will (as I have stated) be proportionate to weight and distance, without regard to speed of motion; for instance, to convey a coach loaded with two tons for a distance of ten miles only, the same fuel will be consumed and the same wear of machinery will be occasioned whether that distance is run in one hour or in four hours. The wages of engineers, conductor, and guard, will be only one-fourth with the quick speed, and the first outlay in machinery would be only one-fourth, because four times as many engines must be on the road, with their attendants, at the same time, to do the work at a slow speed, as at a quick speed; but the money earned by the carrier at the slow speed will be only a small part of what would be earned at the quick speed.

" Taking into consideration the comparative expense of horse-carriages and steam-carriages, do you suppose that steam-carriages will be able to run for half the charges of horse-carriages?"—" My own idea is, that steam-coaches will, very soon after their first establishment, be run for one-third of the cost of the present stage-coaches; but to become a business at all, it must necessarily be a business which will offer strong inducements to persons to embark in it; and to do that, the rate of profit must be very much greater than that which is commonly expected to be realized by the proprietors of stage-coaches; their present trade affords a less profit on the capital and trouble of management probably than any other sort of business which is carried on with spirit in this country. The great reason of that is, the constant loss by destruction of horses, the fluctuations of the price and quality of horse-keep, and the impossibility of reducing stage-coach establishments in times when travelling business is flat; because the horses must be kept and men to attend them at all events, and the loss of running a coach half employed is not so great as suspending it, and keeping the horses idle on short allowance, till better times come round. The profit of stage-coaches which load well is very high, particularly in the fine travelling season, and that occasional profit creates an excitement which induces the injudicious setting up of more coaches than are wanted for an average of all seasons; and for the reasons above stated, their expenses, when once set going, cannot be reduced to meet bad times. The adoption of steam-coaches will set the trade free from its great commercial difficulty, because they can be laid up and kept idle without considerable loss, and brought out again when wanted without any new outlay; also fuel does not fluctuate either in price or quality to any considerable extent like horse corn. In short, the capital embarked in a steam-coach trade will not be so rapidly wasted as at present in horses. Owing to the great number of horses which must be first bought and then kept to do the same work as one steam-coach, the first outlay in stock will be very small in steam-coaches, compared with horses, the same of stables, hostlers and harness. The daily expenses of fuel and attendants will be very much less than that of horse keep and attendance; the wear and tear of the coaches and all that is coachmakers' work will be only the same as at present, but the wear and tear of engines and machinery, though a very expensive item on each engine, will be nothing to compare with the present repairs, loss and decay of horses, because the number of engines is so small. Stage-coach horses require to be all renewed every three years, notwithstanding a heavy annual expense for what may be called repairs of horses; viz. harness, shoeing, and farriery. Engines with an equally heavy annual expense of repairs to that of horses will, when perfected, be kept up thereby in such a state as to last for many years without renewal. The metal parts of machinery only wear at particular places, which are capable of being repaired or renewed, so that they become as good as new; but a horse when worn to disease at any part, feet, eyes or lungs, becomes incapable of stage-coach work for ever afterwards."

"Of course, a steam-carriage going slower than ten miles an hour will be more expensive to travel, on account of the greater expenditure of fuel?"—"No; the consumption of fuel, according to time, would be as much less as the motion would be slower; so that the consumption of fuel, according to distance, would be the same, whether for a quick speed or for a slow speed; but when profit is considered, every thing is in favour of quick speed; because all goods carried slow must be carried cheap; and quick conveyance will bear the highest price of carriage, on account of the expense of going quick by horses. For instance, a ton of goods may be carried a mile by steam-power with a certain consumption of fuel, but it should take no more fuel to carry it a mile at the rate of two and a half miles an hour than at ten miles an hour; there is some qualification to be made in that statement according to the state of the roads; it will be true if they are hard and good, but if they are heavy, the expense of fuel will be a little more for the quick speed than for the slower speed; and it is also to be understood, that the engines must be suitably proportioned for attaining quick speed, because engines which are only adapted for slow motion do not work to so great an advantage when they are urged to work quick as when they are worked at or below the speed which the proportions of their parts are adapted to move with; nevertheless, that extra expense of going quick by steam-power will be but small, and nothing like the increased cost of travelling quick with horses; for horses have only a limited speed at which they can travel if they have no load to carry or drag after them, the whole of their muscular strength being then required to advance the weight of their own bodies; the speed with which stage-coaches now travel approaches so near to the speed with which the horses could travel without any load, that their force of draught becomes very small. In all cases, horses lose force of draught in a much greater proportion than they gain speed, and hence the work they do becomes more expensive as they go quicker. The quickest stage-coach travelling is now at the rate of eleven miles an hour, and that appears to be very near to the utmost limits which nature has prescribed for animal exertion; for those horses require renewal of the whole stock every two or three years. This is a comparison of steam-power and horse labour, during the time that each is actually in operation; but the real difference between the performance of a steam-engine and that of a set of horses will be found to be very great, when it is considered, that by having one spare steam-coach for every two or three which are on the road, those coaches can travel continually all the year round, during fourteen or fifteen hours in every twenty-four hours, without any intermission, except stopping for one or two minutes to take in water at every stage of about seven or eight miles; and thus each steam-coach can travel 140 or 150 miles a-day; whereas a set of four stage-coach horses can only work during seven hours and a half out of every twenty-four hours, or each horse can run fifteen miles a-day, and that exertion wears them out very soon. A cart-horse, travelling at the rate of two miles and a half an hour, can work during eight hours out of every twenty-four hours, or he can travel twenty miles in a day. Suppose that in both cases, of horses going ten miles an hour or only two miles and a half an hour, the force of traction was the same during the time that they were actually drawing; even on that supposition, there would be the difference between twenty miles a-day and fifteen miles a-day in favour of slow travelling; but in considering the work performed, the great loss in the force of draught by quick travelling must be taken into account; and it will be found that a cart-horse, walking at two miles and a half an hour, could draw with a force of traction 100lbs. on an average, but that a stage-coach horse, running at ten miles an hour, cannot exert more than 28lbs. force of traction at an average. The above proportions of distance travelled and force of traction exerted in each case being combined into one product, the proportion will stand thus:—20 miles a-day × 100lbs. draught = 2000, to represent the work done by a horse travelling at the rate of two miles and a half an hour, and 15 miles a-day × 28lbs. draught = 420, to represent the work done by a horse travelling at the rate of ten miles an hour, which is 4¾ to 1 in favour of a slow speed; when with steam power there would be only a very slight difference of performance, at the quick or the slow speed.

Mr. Davies Gilbert, M.P. late President of the Royal Society, and Vice-President of the Institution of Civil Engineers, gave, in his evidence, the following. See Report, p. 58.

"I have some further remarks, which I would beg to deliver in also, tending to point out particularly the advantage of steam conveyance, when the rate of travelling is great. I would beg to add, that it appears to me extremely difficult to lay down any general rule which would be applicable to all situations and all roads, inasmuch as they vary with the nature of the materials: that, up to a certain weight, proportionate to the corresponding width of the wheel, it is probable that the injury to any road may be very little; but that beyond a certain weight, compared again with a corresponding breadth of the wheels, the materials would be entirely crushed, and the road totally destroyed; therefore it follows, that even on all roads there must be a limit to the weight of carriages, as it is quite impossible that a wheel of enormous breadth could bear uniformly on all its surface. For instance, where trains of artillery are drawn over roads, the excess of their weight beyond what materials are capable of sustaining, has been found sufficient for grinding them to powder. The slow conveyance of heavy weights may perhaps be effected by steam on well-made and nearly level roads, so as to supersede the use of horses; but steam power is eminently useful for producing great velocities. It was last year determined by the Society of Civil Engineers, after much inquiry and discussion, that the expense of conveying carriages drawn by horses was at its minimum when the rate of travelling equalled about three miles an hour, and that expense increased, up to the practical limit of speed, nearly as the velocity; including the greater price of horses adapted to swift driving, their increased feed and attendance, the reduced length of their stages, and, with every precaution, the short period of their services; on the contrary, friction being a given quantity, as well as the force requisite for impelling a given weight up a given ascent, the power required for moving steam-carriages on a railway remains theoretically independent of its speed, and practically increases but a very little, in consequence of resistances from the atmosphere, slight impacts against the wheels, inertia of the reciprocating piston, &c. The expenditure of what I have termed efficiency is as actual force multiplied by the velocity, and the consumption of fuel in a given time will be in the same proportion; but the time of performing a given distance being inversely as the velocity, the expenditure of fuel will theoretically be constant for a given distance, and very nearly so in practice. The power requisite for moving bodies through water is in the opposite extreme; here, the mechanical resistance of the fluid increases with the square of the velocity, as do the elevation of the water at the prow, and its depression at the stern. The oars or paddles must, therefore, preserve a constant ratio to the velocity of the vessel; and the force applied will consequently vary as the squares of the velocity; and the expenditure of efficiency being as the force multiplied by the velocity, the consumption of fuel will be as the cube of the velocity in a given time, or as the square of the velocity on a given space; and I have ascertained, from the records of voyages performed by steam-vessels, that the law is nearly correct in practice: hence the great power required for such steam-vessels as are constructed not merely for speed, but also to set at defiance the opposition of winds and seas; while, on the contrary, a very small power will be found sufficient for moving ships of the largest dimensions through the water, at the rate of two or three miles an hour, when their sails are rendered useless by continued calms."

The evidence of Mr. Goldsworthy Gurney, inventor and patentee of the steam-carriage after described, was as follows:

"What do you calculate to be the comparative expense of running a steam-carriage and running a coach with four horses?"—"That varies in different situations, according to the price of coke and the price of labour; it is in all cases considerably less, at least one-half less."

"You anticipate that the principal use of steam-carriages will be the conveyance of passengers, and at one-half the expense at which they travel now?'—"Yes; and in less time."

"Can you deliver in to the Committee a detailed estimate of the expense of running a steam-coach, and one of running an ordinary coach?"—"Yes, I will prepare them."

"At what rate do you suppose it would be safe to run steam-carriages on the public roads?"—"I have run them safely eighteen and twenty miles an hour; but twelve miles an hour is perfectly safe and practicable; the rate will be determined by practice principally in directing the carriage at present: there is no difficulty or danger in guiding the carriage at this rate."

Calculation as to the relative expenses betwixt Horse and Steam Power for locomotion.

"In order to estimate the comparative expense between *horse* and *steam power* for drawing carriages on common roads, I will take the relative expense on 100 miles of ground for working a common stage-coach *by steam* and *by horses*.

"The first cost, wear and tear of the coach *drawn*, in every respect is the same in both cases.

"The expense of men to manage is about the same also. In one case there is a coachman and guard; in the other, an engineer and director.

"*Government duty* and *turnpike-tolls* must also be considered the same.

"It remains then to show the difference in the expense of POWER only; viz betwixt the expense of horses and the expense of steam. First in the outlay on 100 miles of ground. To work a coach well with horses 100 miles up and 100 miles down once a-day will require 100 horses. A horse a mile is the present calculation for doing the work. If these horses be taken at 20*l.* or 30*l.* per horse, or say 25*l.*, it will amount to 2,500*l.* *Three* steam-carriage will do the same work, and the expense of these will be about 500*l.* each, or 1,500*l.* for the three. A saving will consequently be effected in the first outlay of 1000*l.* in capital.

"The wear and tear of horses may be estimated at about 5*l.* each, per annum, on the 100 horses; viz. 500*l.* per annum.

"The wear and tear of the three steam towing-carriages will not exceed 100*l.* each per annum; 300*l.* for the three; saving in wear and tear 300*l.*

"The expense of shoeing, keep, provision, attendance, harness, &c. is, per day, somewhere about 3*s.* each, or 15*l.* upon the 100 horses.

"The expense of fuel for two carriages, one up and the other down, doing the same work, will be that of 100 bushels of coke at 6*d.* per bushel; say 2*l.* 10*s.*

"Or if we take 1*s.* *per mile* per horse power, it will be about the same. The expense of fuel for the steam-carriage will be, on an average, throughout England, about 3*d.* In some coal districts it will not exceed 1*d.* per mile; while in other situations it will amount to 6*d.*

"I have not taken into this estimate the expense of stables, which is considerable, when compared with sheds for coke and water.

"From these data I conclude the carriage may be worked by *steam* at one-fifth the expense of horses."

ABSTRACT.

HORSE-POWER.	£.	*s.*	STEAM-POWER.	£.	*s.*
Outlay for horses	2,500	0	Outlay for steam-carriages	1,500	0
			Balance of saving in the outlay in favour of steam-power	1,000	0
Wear and tear of horses, per annum	500	0	Wear and tear of steam towing-carriages . .	300	0
			Balance, saving in tear and wear in favour of steam-power	200	0
Shoeing, keep, attendance, provision, harness, &c. per day, for 100 horses	15	0	Fuel for steam-carriages, half-bushel per mile travelled, at 6*d.* per bushel	2	10
			Balance, saving	12	10

"Have you any additional evidence to give to the Committee on points which you have considered after your last examination?"—"I have no further evidence in connexion with the practicability of the carriage."

"Would you wish to explain your former evidence, or to give any additional evidence upon the subject?"—"On looking over the evidence I find it correct. I should observe in explanation, that at 3*s.* a-day I have taken in the wear and tear of the horses, and the attendance, and the fuel."

"How long are your boilers calculated to last?"—"About three years fair treatment."

"How frequently do they require examination?"—"Once a fortnight or three weeks; it depends on the situations where they work: in some situations where lime is held in solution in the water in large quantities they require cleaning oftener, but in other situations where there is very little earthy matter held in solution they will run for a month or two months."

"Is there a facility of cleaning them?"—"There is, from recent improvements in cleaning, very great facility."

"Is there any expense attendant on the operation of cleaning?"—"One day's work of a labourer, their not requiring an engineer."

"Have you any thing further that you wish to state to the Committee?"—"I would state generally, in regard to the main improvements on steam-engines, by which this country has been so much benefited, and the prospects of advantages arising from steam-carriages, that they have almost always been in a direct ratio with that of removing of horses; that the great and splendid improvements of Mr. Watt have generally been supposed to be principally connected with the separate condenser of the steam-engine, and the saving of the fuel; but before Mr. Watt's day, we could empty our mines of water in Cornwall, and we could do a variety of other simple work by the steam-engine, and so far the improvement of Mr. Watt was simply with respect to the saving of fuel; but I consider that the great national advantage arising from Mr. Watt's improvement has been his application of the steam-engine to machinery; and the extent of that advantage to the community has been in a direct proportion to the removal of horse-power, a most unproductive labourer and a dead expense to the country. If this view of the subject be entertained, the application of steam to propelling carriages on common roads will be as important above its application to machinery generally, as the number of horses employed in locomotion exceed those necessary to machinery, which bears no proportion with respect to each other. At Hounslow alone, there are at this moment upwards of 1,000 horses employed in stage-coaches and posting. On the Paddington road, a distance of five miles only, there are upwards of 1,000 horses employed at this moment. Throughout Great Britain it is almost impossible to say how many horses are employed, but I should perhaps be within bounds if I were to say millions, in posting and stage-coaches. If it is possible to remove those horses by an elementary power, which I firmly believe is practicable, the national advantage must be in proportion to the number of horses so removed; for if it is shown that one carriage-horse can be removed from the road by the present state of steam-carriages, I see no reason why every horse so employed should not be so removed. It has been decided that the condanger which would be incurred by the change; and if the engines and passengers are not on the same carriage, I think the ordinary danger would on the whole be diminished."

"The question is with reference to the relative danger of travelling ten miles an hour when drawn by horses, and when propelled by steam at the same rate?"—"The danger of being run away with and overturned is greatly diminished in a steam-coach. It is very difficult to control four such horses as can draw a heavy stage-coach ten miles an hour in case they are frightened, or choose to run away, and for such quick travelling they must be kept in that state of courage, that they are always inclined for running away, particularly down hill, and at sharp turns in the road. The steam-power has very little corresponding danger, being perfectly controllable, and capable of exerting its power in reverse, to retard in going down hill; it must be carelessness that would occasion the overturning of a steam-carriage, which carries the passengers in the same carriage with the engines. The distinct carriage I consider to be much less controllable in turning corners and going down hill, but yet far more so than horses. The chance of breaking down has hitherto been considerable, but it will not be more than usual in stage-coaches, when the work is truly proportioned and properly executed. The risk of explosion of the boilers is the only new cause of danger, and that I consider not equivalent to the danger from the horses. There have been, for several years past, a number of locomotive engines in constant use on railways, all of them having large high pressure boilers, very much more dangerous than Mr. Gurney's or Mr. Hancock's, whether we consider the probability of explosion, or the consequences likely to follow an explosion, because, being of large diameters, they are less capable of sustaining the internal pressure of the steam, and also they contain a large stock of confined steam and hot water. The instances of explosion among those locomotive engines have been very rare indeed."

"Have you seen Mr. Hancock's[1] last improvement?"—"Yes; I consider Mr. Hancock's boiler to be much better for steam-coaches than any other which has been proposed or tried."

"If that boiler were to explode, it is understood that there would be no danger at all?"—"It is very difficult to foresee that; at the same time the risk of explosion in Mr. Hancock's boiler is certainly very much less than in the locomotive boilers which are in constant use on a large scale on railways, and where we have proof that the extent of the danger is very small."

"Do you think his boiler might explode without the passengers knowing any thing about it?"—"The metal plates of which the boiler is composed will burn through by the continuance of the action of the fire, and may crack or open so as to let the steam or water out of the boiler and disable the coach from proceeding, but that is hardly to be called an explosion; no one would be hurt; the crack which lets out the hot water is sure to throw it into the fire in that case, and not on the passengers."

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[1] The comparative merits of Mr. Hancock's, Mr. Gurney's, and other boilers, will be discussed in the following pages.

"You consider the danger to passengers by the chance of bursting of a boiler as not equivalent to the danger of horses running away?"—"It is not equivalent in my opinion; the probability of a coach being overturned by the horses is far greater than that of a boiler bursting, and when either accident does occur, the probable extent of mischief from an overturn in which all the passengers must participate, is much greater than could be expected from the bursting of a boiler, which must always be kept at a considerable distance from the passengers on account of the heat."

"Supposing either Mr. Hancock's or Mr. Gurney's boiler were to burst; in the one case the boiler being in a separate carriage, and in the other the boiler being at a considerable distance behind the passengers, what danger do you think could arise to the passengers from the bursting of the boiler?"—"There is very little difference between the two cases; the separate carriage obviates any apprehension that passengers could entertain from the danger of explosion, and will therefore be preferred by most passengers, but for myself I do not rate that risk so high as to be induced to encounter the complexity of the two carriages, and to forego some of that new security which steam-power offers by its controlability in descending hills and turning corners, compared with horses; and in which circumstance, as I have before stated, I think the plan of one carriage is much to be preferred, and probably the other objections of heat and noise and dust may be overcome by some new means, which have not yet been shown: in Mr. Hancock's carriage the boiler is quite behind, and away from the passengers, so that they are out of danger, if there is any, and are not materially annoyed by heat or smoke, and dust, except at times when the wind brings it forwards, and that rarely happens when the coach is moving."[1]

"Is not the danger attendant on the bursting of the boiler greatly diminished by the subdivision of its internal capacity into tubes or small and flattened chambers?"—"Unquestionably, until the danger of explosion has become exceedingly small."

The actual casualties of stage-coaches, however, we may observe, bear no proportion to the loss of lives from consumption and other diseases occasioned by cold and wet, from exposure on the top of coaches[1].

Let us consider also how far humanity is outraged by the present system of quick travelling. The short average life of stage-coach horses (three years only!) shows how dreadfully over-wrought and *out-wrought* they are by the great speed now in practice. Driven for eight or ten miles, with an oppressive weight, they tremble in every nerve. With nostrils distended, and sides moving in breathless agony, they can scarce, when unyoked, crawl to the stable. 'Tis true they are well fed; the interest of their owners secures that. They are over-well fed, in order that a supernatural energy may be exerted. The morrow comes when their galled withers are again to be wrung by the ill-cushioned collar, and the lumbering of the wheels. But we do not witness all the misery of the noble and the generous steed. When the shades of night impend, the reproaches of the feeling, or the expostulations of the timid, traveller no longer protect him from the lash; and the dread of Mr. Martin's act ceases to effect for a time its beneficent purpose; when the stiffened joints—the cracked hoofs—the greasy legs—and stumbling gait of the worn-out animal, are all put into agonized motion by belabouring him *upon the raw!* The expression is Hibernian, but the brutality is our own. A few ill-gained pounds reconcile the enormity to the owner—and the cheapness and expedition of the conveyance give it public sanction: but humanity is outraged by the same: human sympathies are seared; and the noble precept, that "the merciful man is merciful to his beast," is trampled under foot.

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[1] It appears from the newspapers that on the night of the 25th February, 1812, three outside passengers were found dead on the roof of the Bath coach from the inclemency of the weather.

Thus then, by substituting elementary for physical power, we have comfort for comparative inconvenience—the inside of an elegant apartment, where books, amusement, or general conversation may occupy agreeably the time—for the outside of a hard, unsafe stage conveyance, and exposure to all changes or varieties of atmosphere. Nay, we see no reason to prevent such improvement in steam-carriages as shall fit them up like steamboats, the campaigning carriage of Napoleon, or the travelling long coach of the present Duke of Orleans, with beds, and a furnished table. We have besides safety for danger—accelerated speed without inhumanity—gain of time—of accommodation—of money—and over and above all, as a non-consumer of food, we have by the substitution what will remove the host of Malthusian ills to a period of almost indefinite duration.

CHAPTER II.

THE MEANS BY WHICH AN ELEMENTARY POWER IS OBTAINED AS A SUBSTITUTE FOR ANIMAL POWER.

THE source of steam or elementary power is heat. A limited quantity is generated by the combustion of a limited quantity of fuel; and if this can be embodied and suddenly abstracted, it can be made applicable to locomotion, or any other purpose of mechanical agency. It may, however, be embodied and produce a powerful effect, although it cannot be suddenly abstracted, but then of course it is not applicable to machinery.

A beautiful instance of this occurs in the preservation of the Conservatoire des Arts et Metiers at Paris, the walls of which had begun, owing to the weight of the roof, to recede from each other. Iron bars, with screws and dises on each end, were inserted and passed through both walls—the bars were heated, and in their expanded state the dises were screwed up close to each wall. In cooling, an enormous power was exerted by the contraction of the bars which drew the walls back into their proper position. It is impossible to deny that heat is the cause of power: and that power is not in proportion to the quantity of heat generated, but to the quantity which can be embodied in a state disposable for use.

That state in which it is most disposable for use is when the heat has been imparted to water and formed the vapour steam. A low pressure or condensing steam-engine, by having the steam instantly condensed again into water, will illustrate this. Here the heat has entered the water, formed the steam, and a cold application depriving the steam of its heat reduces it to water again. Now water of one bulk, say a cubic inch of water, when formed into steam, occupies 1700 bulks, or 1700 cubic inches: and it is by throwing heat into the single bulk of water, thus increasing its bulk 1700 times, and then by abstracting that heat with a cold application, so as to reduce the 1700 bulks to one bulk again, that power is produced in the low-pressure engine. It is this generation and destruction of heat that produces the movement of dilatation and contraction. A chemical movement thus obtained is easily applied in a machine by the engineer, so as to maintain the power which can "engrave a seal, and crush a mass of obdurate metal like wax before it; draw out without breaking a thread as fine as gossamer, and lift a ship-of-war like a bauble in the air;" which "can embroider muslin, forge anchors, cut steel into ribands,"—and impel itself against the opposition of the very tempest.

Another mode of obtaining power in a steam-engine from heat imparted to water is by high-pressures: and it is this modification of the steam-engine which is used for steam-carriages.

A short description for the general reader may be deemed an essential part of a work of this kind.

All high-pressure steam-engines consist of a boiler, or generator of steam, and of a working-cylinder, where the steam is applied—and of a water-pump which feeds the boiler with a fresh supply of water in the place of the water which has been evaporated.

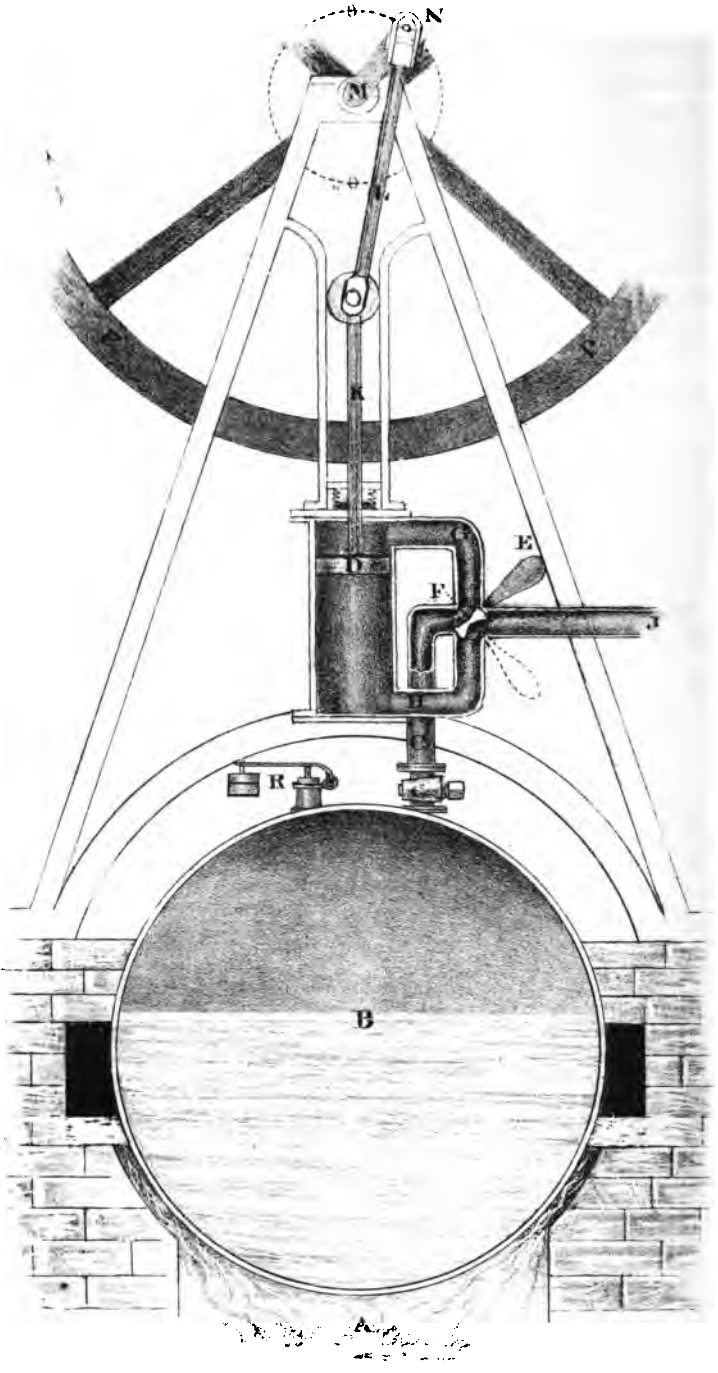
Plate I. is intended to show how the operation takes place.

A, the fire-place, where heat is formed by combustion of the coals or other fuel.

B, the boiler, about half filled with water. In the upper part of this boiler, above the surface of the water, is the space occupied by the steam. The heat below has been transmitted to the water. The water has boiled, and in its ebullition keeps generating more steam. If the fire be kept brisk, and no passage provided for the steam to escape from, it is clear the steam must be confined or pent up, and more ready to rush out at the first vent. More and more heat is applied below. The water absorbs it, and more and more steam is generated, which steam, from every thing being closed, is very much pent up, and is in the state called high-pressure. Of course, if we still keep adding heat, and generating steam, the pressure within will be too great for the strength of the boiler to stand, and the boiler will burst. Some steam-engines are intended for work with one pressure, and some with another. There are steam-engines which work with 30lb. pressure upon each square inch of the boiler, and those which work with 200lb. pressure upon each square inch.

At first it would appear that the high-pressure engine is more

Plate 1.



dangerous than the low-pressure engine. But such is not found to be the case in practice. In all cases where high-pressure boilers have been attended with danger, there has been the most gross and culpable neglect: under which the same thing would have, and has happened, with low-pressure engines; and in almost every case of sudden explosion the boilers have been made of cast-iron instead of wrought-iron: and it may have the effect of removing all fear when we say that some recently-invented boilers, such as Gurney's or Hancock's, described below, are completely free from danger.

When the steam is raised in the boiler B, and ready for use, we open the cock C, and the steam will flow up the pipe C, and past G, and press the piston D in such a manner, that D will descend, pushing before it the air or vapour which is below it, and in the pipes leading from the lower part of the cylinder. This air or vapour will be driven along the pipes, and through H F out into the atmosphere J, where it will be dissipated. It will now be seen that the piston D has traversed from the top to the bottom of the cylinder. Now if the handle E (the handle of a cock, F) be turned into the dotted position, it is clear the cock it acts upon will have a similar movement, and open the communication from G to the atmosphere J; whilst the communication C F H will be opened from the boiler, to allow the steam to act on the under side of the piston D to press it up again.—Thus the piston will alternately be raised and depressed; and so long as the boiler supplies steam this alternating motion will be continued: the cock (valve) F being turned at each movement so as to allow the steam to press on the one side of the piston, whilst it allows the steam at the other side to rush off into the atmosphere at J.

But the turning of the cock (or valve) is not a manual operation. The hand is only applied to it when starting or stopping the engine. When the engine is at work, she opens and shuts for herself; a simple piece of mechanism, appropriately called a tappit, striking the handle E on the one side or the other as required. We have not shown this, lest the drawing should be too complicated. Suffice it to say, the engine can be made to do it. The mode will appear simple hereafter.

When the piston D is driven from one end to the other, like a shuttle-cock, it will be obvious that the piston-rod K is driven with it. This rod is connected by another rod L, which acting upon the crank M, turns it round, describing the dotted circle in the direction of the arrow. Thus, from the alternating rectilinear motion of the piston a continuous circular motion is obtained. But it will be seen that when the part marked N reaches in its revolution either of the points O, there will be an uncertainty which way it would turn to go the next circle: it might falter and go back again. In stationary engines a heavy fly-wheel P helps the motion to continue over these centres, as they are called. In steam-carriages, however, the weight of a fly-wheel is so great that it cannot be used, and therefore two engines are used to the same boiler; one engine always being in full force when the other is passing the centre—so that there is a continuous and unimpeded motion round the circle.

The power of the engine is calculated by the effect it produces in moving the piston at a given speed, from end to end of the cylinder. Suppose the steam presses on the side of D next the boiler with a force equal (say) to 50 lb. on each square inch, and the force of the atmosphere, 15 lb. on each square inch, is all that opposes the movement of the piston; the difference betwixt the 50 lb. pressure of steam and the 15 lb. pressure of the atmosphere is 35 lb.; and if the area of the whole piston D be 28 square inches, we have a positive pressure of 980 lb. to move the piston D up to the other end. When it arrives at the upper end the cock F is turned, so as to allow the steam to enter at the other (that is, the upper) side of the piston D, to drive it back again. We have already shown how the steam below the piston is got rid of; it (at 980 lbs. pressure) rushes off into the atmosphere.

The *steam* blown away requires to be repaid to the boiler in *water*, which is done by a little pump worked by the engine.

There is in the steam-engine "a circulation like that of the blood in the veins of animals, having valves which open and shut in proper periods; it feeds itself, evacuates such portions of its food as are useless, and draws from its own labours all which is necessary to its own subsistence."

R is a safety-valve which is of a certain weight, or having weights on it. Say in the present instance that the area of the valve is one square inch; then the weight on it must be 50 lb. It will easily be seen, that if by neglect or any other cause too much steam or too great a pressure of steam should accumulate in the boiler, this valve will rise, the steam will blow away, nor will it shut again so long as the steam is at a pressure above 50 lb. per square inch, which it is, in this instance, intended to work to. The valve may be so adjusted as to blow open at a single pound pressure, at 300 lb. pressure, at any intervening pressure, or any higher pressure.

It is unnecessary to follow out this description. The steady and continued power being thus obtained, can be adapted to a variety of movements, "and drag the slow barge or drive the rapid car."

We have said above, that if the pressure of the steam was allowed to go on accumulating in the boiler without an exit being found for it to escape by, the boiler would burst, and of course the larger the boiler the greater the chance of danger. The safety-valves—for generally there are two, lest one should be deranged—are sufficient to prevent the accident of explosion. Indeed the bursting of a well made wrought-iron boiler is of very rare occurrence. In the course of the next chapter, the causes of explosion, and the successful means of completely preventing danger, when such an event does occur, are more fully discussed.

The late Mr. Murdoch, of Soho, made several calculations and some experiments for a locomotive engine, in conjunction with the late Mr. Gordon, in the year 1819, for the purpose of introducing compressed air as the immediate motive-power. But the compression of aeriform fluids was then in its infancy, and they were on that account discouraged in their proceedings. Their object was to store up power in the elastic air, compressed highly, and to let it down into a piston-engine by degrees, instead of steam. This may be more easily explained to some readers by the example of a watch or time-piece, in which the power of the winder's hand is stored up in the spring, and allowed to unwind itself and operate by degrees in making the watch go.

If we squeeze a sponge which is in good condition, we squeeze out the air contained in it, and when we relax our grasp, the sponge again distends itself and fills its cells with air. Suppose then that we squeeze or compress a cubic foot of air by an apparatus made for the purpose. In so doing we squeeze out the latent heat contained in that cubic foot of air. Still continuing the pressure, we press out more heat. The cubic foot of air is now reduced, say to one-thirtieth part of its original bulk. But as this is an unnatural state for it to remain in, there is a tendency in it to dilate in proportion to its density. Care must be taken to keep it tightly pent up until the power thus stored is wanted.

Suppose that we wish to use this power, we allow it gently to escape, which it will do at any opening, however small. It expands instantly, satisfying its avidity for the heat formerly forced from it as it expands by taking heat from surrounding objects, and the circumambient air. Thus a power is got, which is the movement from a state of compression to a state of dilatation—a movement somewhat similar to the expanding movement of high-pressure steam described above.

The apparatus which compresses this air is kept cool by cold water externally applied, otherwise the quantity of heat forced from the air would make the pumps red hot. So also the expansion of the air must be well provided for, otherwise the cold produced is so intense that the machinery may be clogged up by a deposition of ice or snow. The surrounding atmosphere, robbed of its heat by the expanding power, deposits its moisture in a state of ice or snow.

This would be an interesting subject to illustrate farther by a variety of phenomena, which the extensive compression of carburetted hydrogen gas and atmospheric air by the late Mr. Gordon have made us acquainted with, but at this early stage of experiments upon locomotion by compressed air, such is unnecessary.

The Earl of Dundonald (the gallant and ingenious Lord Cochrane) is now making extensive experiments in pneumatic engines, to be propelled by compressed air. And from the mechanical ingenuity and scientific observation of that nobleman we may expect the most happy results.

Certainly a store of power carried in this manner would be of very great advantage, where the steam-engine itself may be objected to. The flow of compressed air, from the reservoirs to the piston engine, could be rendered as easily manageable as any steam-engine. Experience alone can determine the point of expense. But I am sanguine enough to expect that a few years may see its introduction as a noiseless and agreeable motive power for locomotion, in crowded streets and pleasure rides.

It is believed that Mr. Medhurst, who obtained a patent in 1799, was the first to propose working machinery by means of compressed air, but at that period the compression of air was ill understood, and had not been practised to any extent. Mr. Lemuel Willman Wright obtained a patent in April, 1828, for the application of compressed air to work machinery; and Mr. Mann obtained a patent in 1829, for applying compressed air as the motive-power of carriages; but there has as yet been no scheme for using compressed air made public, which can be safely engaged in.

An engine, which created a considerable interest in 1824 and 1825, was invented by Mr. Brown of Brompton, named a gas-vacuum engine, in consequence of a partial vacuum being formed by the combustion of carburetted hydrogen, or any other combustible gas, and atmospheric air. The inventor applied the effects of the vacuum thus produced to the movement of a piston in a cylinder, and he deemed it particularly available for the purposes of locomotion. A power was got in a piston-engine, and a locomotive carriage was, on more than one occasion, propelled for some distance by this engine. Small paddle-boats were also exhibited on the Thames. But the use of the piston-engine seems now to be abandoned by Mr. Brown.

As a machine for raising water it has been more prosperous, although in its most perfect state far inferior to the steam-engine, on account of the expense of the gas required.

That some notice of this engine comes within our province will be allowed, when we state that the late Mr. David Gordon, the inventor of the portable gas-apparatus and of two locomotive-engines (Plates V. and VIII.) impressed with the great importance of locomotion, originated a society of gentlemen in 1824, "tending to the ultimate establishment of a company for the purpose of contracting to run the mail-coach and other carriages, by means of a high-pressure steam-engine or of a gas-vacuum or pneumatic-engine, supplied with portable gas."

The committee of that society had only a limited sum at their disposal, nor were there to be more funds until a carriage had been propelled for a considerable distance at the rate of ten miles in an hour. Mr. Gordon soon saw that his expectations, in regard to the gas-vacuum engine, had been too sanguine, and immediately endeavoured to get the committee to proceed with a steam-engine. This unfavourable view of the gas-vacuum engine was formed from seeing the quantity of gas required in the engine's working, and from the expense of compression to render the gas portable. If the expense of compression can be borne, we conceive it will be for the purpose of high-pressure air, in which case the carriage will be propelled by the expansion of the compressed air into the piston-cylinder, as above described; calculating the value of coal-gas to be three shillings per 1000 cubic feet, (and it is the cheapest gas), the expense of this engine is very greatly beyond that of a steam-engine. If it were used as a piston-engine for locomotion, the gas would have to be compressed into the portable shape, which would add, at the very least, three shillings and sixpence per 1000 cubic feet more.

Various schemes have been proposed for using gunpowder as a portable and powerful first-mover; but the danger of gunpowder, and its very great expense, except when used for projectiles, are sufficient reasons for abandoning the hope of its being made available for locomotive purposes.

In March, 1831, I proposed to several military engineers the extension of the beautiful and accurate science of projectiles for the purpose of inland communication; and my MS. was about that time recorded in the library of the Royal Engineers at Chatham. Its title was, " Message-shells a substitute for the Telegraph and Mail :" and my object was the projection of elongated cylindrical hollow shot, by parabolic curves, three miles at their base. The shells were to contain letters and despatches.

Many experiments have been made for the purpose of obtaining some other liquid than water, which could at a lower temperature and cheaper rate, be converted from the liquid to the aeriform state, and again condensed by the application of moderate cold: and in the Philosophical Transactions, 1823, will be found some interesting papers by Mr. Faraday, and also by Sir Humphry Davy, who had in view the generation of different gaseous bodies under pressure, with the hope that, from the facility with which their elastic forces might be diminished or increased, by small decrements or increments of temperature, they would be applicable to the same purposes as steam. Mr. Faraday ascertained that the vapour from fluid carbonic-acid exerted a pressure of thirty-six atmospheres, but says the application of such a gas as a mechanical agent will be attended with some difficulty; and in his paper, read before the Royal Society, he says, " The small differences of temperature required to produce an elastic force equal to the pressure of many atmospheres, will render the risk of explosion extremely small; and if future experiments should realize the views" developed in that paper, "the mere difference of temperature between sunshine and shade, and air and water, or the effects of evaporation from a moist surface, will be sufficient to produce results" equal in effect to the steam-engine.

About this time Mr. Gurney, who had stated, in his public Lectures on the Elements of Chemical Science, in 1822, that "elementary power was capable of being applied to propel carriages along common roads with great political advantage, and that the floating knowledge of the day placed the object within our reach;" seeing the accounts of such experiments, and with the view of satisfying himself, and showing the true bearing of such propositions, in the institution with which he was connected made a course of experiments, in which he found that ammoniacal gas was manageable. This gas, like steam, being absorbable in water, under reduced temperature and pressure, and being given out again with considerable force by heat, offered properties available for a motive power, capable of being worked with the ordinary apparatus of the steam-engine, or at least without requiring much alteration or change in the mechanical arrangement; and he constructed a little locomotive-engine which acted by this power with great regularity. This experimental apparatus was eventually made the basis of a steam-engine, with which his first experiments in locomotion on common roads were made.

In 1825, Mr. Mark Isambard Brunel, obtained a patent "for certain mechanical arrangements for obtaining powers from certain fluids, and for applying the same to various useful purposes." He gave the preference to carbonic acid gas. Still there was the great mechanical difficulty attendant upon the high-pressure of 30 atmospheres, *above which* his engine must work. No machine yet made could keep sound and free from leakage at such a constant pressure.

From these experiments, however, we may infer, that ere long the vapour of ammonia may be successfully brought into use as a prime mover. Meantime we have a safe, economical, and certain power in the steam-engine, sufficient for those extensive operations with steam-carriages on turnpike roads, which are contemplated in the first chapter of this work.

CHAPTER III.

THE RISE, PROGRESS, AND DESCRIPTION OF STEAM-CARRIAGES.

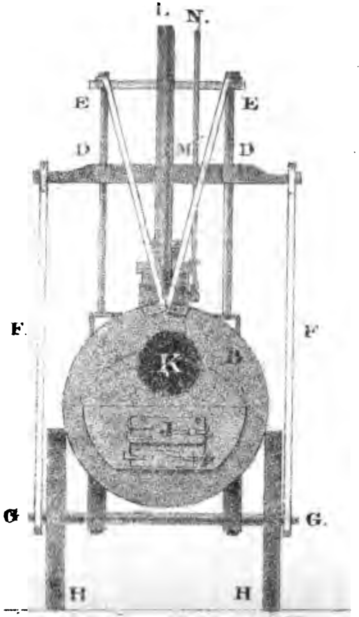
So early as the year 1759, Dr. Robison, (subsequently Professor of Natural Philosophy in the University of Edinburgh,) then a student at Glasgow, threw out the idea of applying the power of the steam-engine to the moving of wheel-carriages.

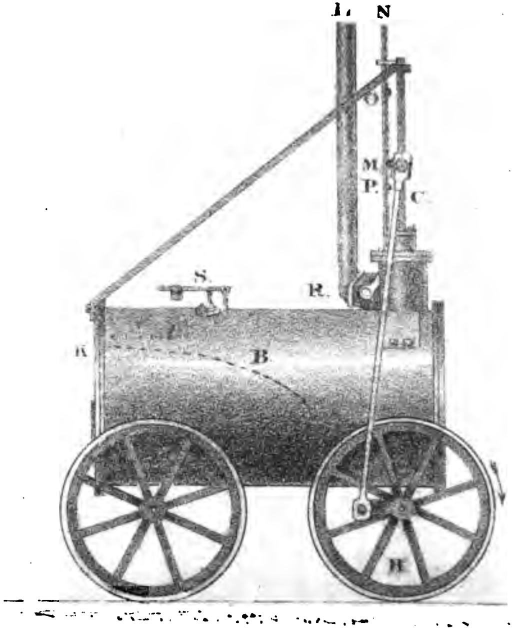
In the year 1772, Oliver Evans, an ingenious American citizen, then apprenticed to a wheelwright, laboured to discover some means other than animal power for propelling land-carriages. He was accidentally made acquainted with the power with which steam is generated from a small quantity of water in the breech end of a gun-barrel, plugged up tight, and placed in a smith's fire. He was fortunate enough to find a book describing the old atmospheric steam-engine, and was astonished to observe that the steam was only used to form a vacuum, instead of being rendered available by its elastic power. Amidst much ridicule, he confirmed his discovery by experiments.

"In the year 1786, he petitioned the legislature of Pennsylvania for the exclusive right to use his improvements in flour-mills, and his steam-waggons, in that State. The committee, to whom the petition was referred, heard him very patiently while he described the mill improvements, but his representations concerning steam-waggons made them think him insane. They, however, reported favourably respecting the improvements in the manufacture of flour, and passed an act granting him the exclusive use of them as prayed for. This was in March, 1787, but no notice is taken of the steam-waggons."

A similar petition having been presented to the legislature of Maryland, that legislature, upon the argument that the grant

Plate 2.





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could injure no one, conferred upon Evans, for a term of fourteen years, after 1787, the exclusive right of making and using steam-waggons in that State.

Although it does not appear that any thing more than a good high-pressure fixed engine resulted from his labours, we cannot omit a very striking prediction in the work of this great projector. "And I verily believe," says he "that the time will come when carriages propelled by steam will be in general use, as well for the transportation of passengers as goods, travelling at the rate of fifteen miles an hour, or 300 miles a-day on good turnpike-roads."

In the year 1784, Mr. James Watt, whose wonderful genius, it may be said, *broke in and trained* the steam-engine, took out a patent, amongst other improvements of the steam-engine, for a mode of applying it to wheel-carriages.

In the year 1802, Mr. Richard Trevethick invented a high-pressure steam-engine and boiler in one machine, of a very compact and complete kind.

Plate II. gives a side and end view of this invention on four wheels. The boiler was made of cast-iron, and had the fire-place in the interior of it, as shown in Plate I. Into the boiler B, at one end of it, was fixed the cylinder, and the steam being supplied to the engine as described above in Chapter II, the piston [1] was raised or lowered. At the top of the piston-rod C it will be seen there is connected a cross-beam D: the ends of this cross-beam are kept parallel by the vertical round rods E, thus preventing the piston-rod from bending to the one side or to the other. From the end of D descend the connecting rods F, which are made to embrace crank pins G on the front wheels on each side of the machine. When these connecting rods are raised and lowered by the alternating motion of the piston, the two wheels H will be turned in the direction of the arrow, and the machine will advance along the road from left to right. This movement, however, of the wheels, will not always be attended by the same effect. For instance, suppose the wheels H H were placed on a piece of smooth ice, or greased board, the alternate rising and falling of the piston and its rotary motion conveyed to the wheels, might fail in effecting a progressive motion of the carriage, because the wheels H H, being placed on a slippery surface, would just slip round in the same position upon the ice or greased board. But if, instead of there being a slippery surface under the wheels, there be placed a rough surface, the wheels would then not slip; and as the power of the steam must go somewhere, and cannot slip the wheels, it forces the whole machine onward. This may be resembled to the operation of helping a cart forward by pulling or pushing the wheels round: an example of every day occurrence.

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[1] This drawing I took from the first model of the locomotive-engine which Mr. Trevethick made. I am indebted for it, and other information, to Mr. Partington, the historian of the steam-engine, who used this model in his public lectures at the London Institution, and other places.

Mr. Trevethick, in the carriage which he constructed in 1804, used only one cylinder, and got over the difficulty of his centres by the momentum of the carriage when in motion.

It will not be a matter of surprise, that, at a period when turnpike-roads were very ill made, after experimenting on the present site of Euston Square, and a few other places, the inventor discontinued his attempts on common roads, and confined his operations to a rail-way.

Even here there was a difficulty. Rails were not always laid on a dead level; and in attempting to ascend inclined rails, the adhesion of the wheels to the rails was too slight, and the carriage could not be forced up without projections on the outer part of the wheel, or some other roughness, all of which tended to injure the rail-way.—J is the fire-door. The fire is in a cavity made in the inside of the boiler, and occupying the space shown by the dotted line. K is the chimney; L the waste steam-pipe through which the waste steam is puffed off into the air. Upon the cross beam D there is a little projection at M, which acts upon two similar projections on the valve rod N. As the cross beam D rises or falls, it will strike either O on its under side, or P on its upper side, and this movement of the rod N, up or down, opens or shuts the steam-valve R. S, the safety-valve.

Mr. Blinkinsop, to obviate the difficulty of the wheels slipping, took out a patent in 1811, for a rail-way, with a rack at the side of it, as shown in Plate III. fig. 1. This rack was for a large toothed wheel to work into. There were two cylinders, B and C, for the purpose of each piston helping the other over the centre, as explained below. The cross-heads of the piston rods worked in parallel motions, D D, to the outside of each of which

Plate 3.

Fig: 2.

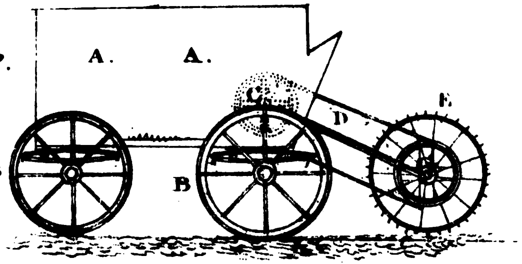
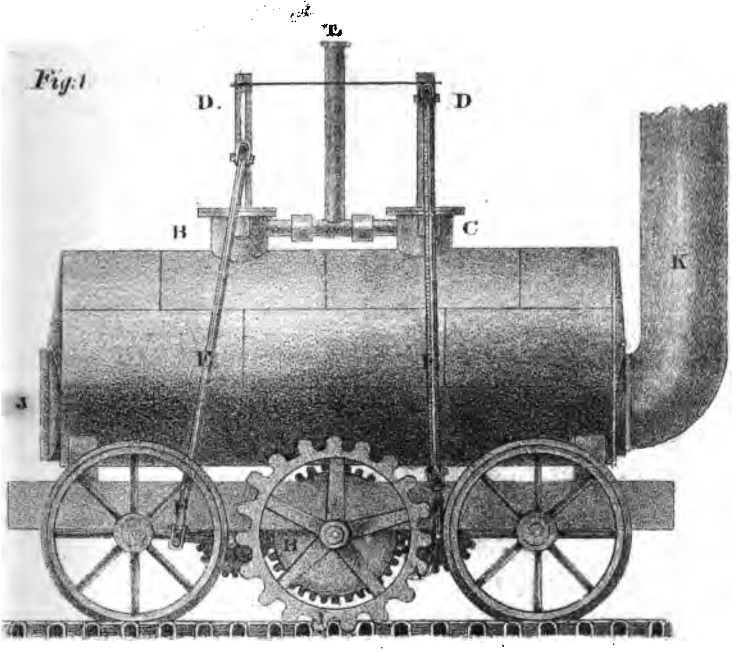


Fig:1



J. Gordon del. et Lith.

Plate 4.

Fig: 1.

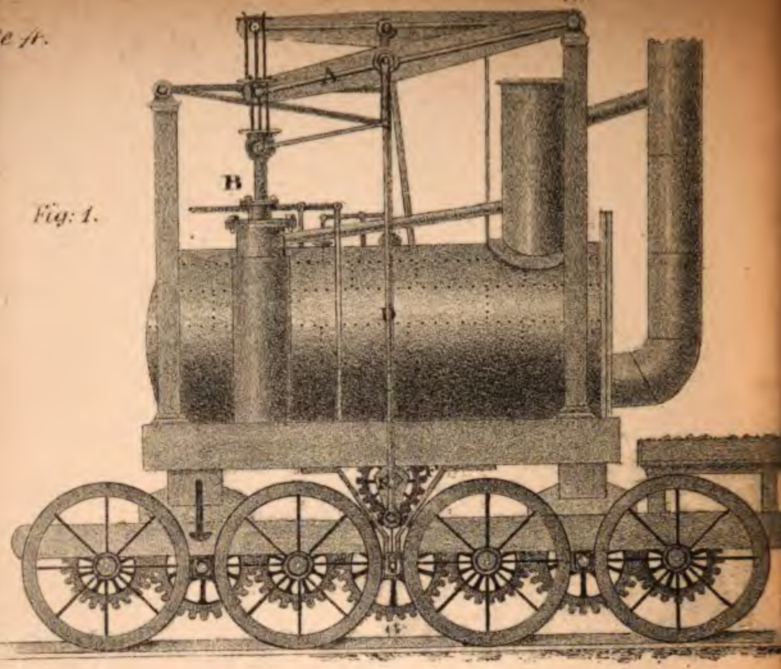


Fig: 2.

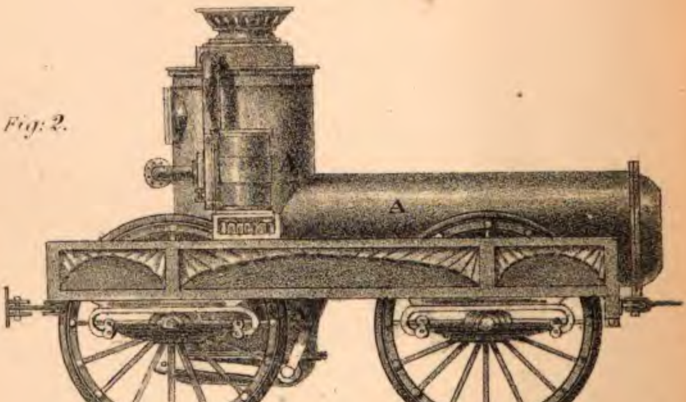


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Plate 5.

Fig: 1.

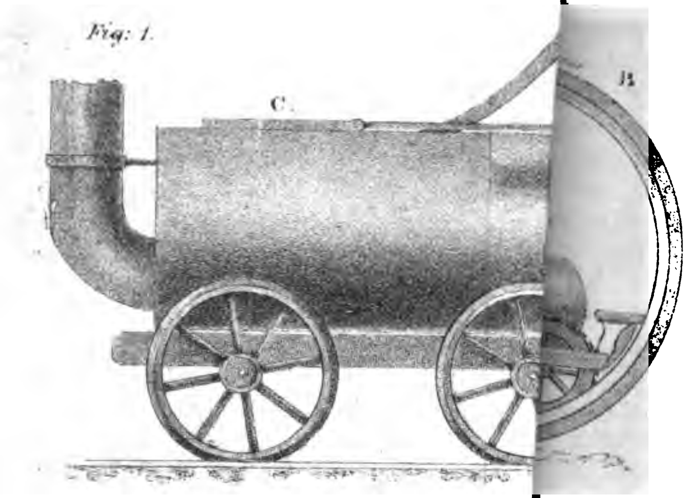
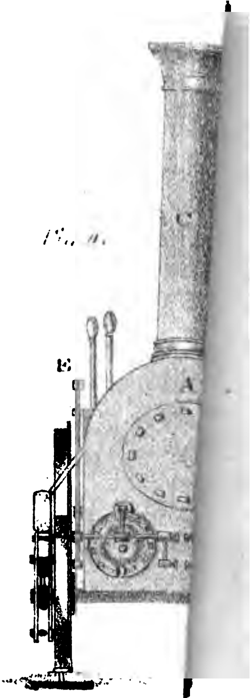


Fig: 2.



they projected, and to these projections the connecting rods E E were attached by brasses, straps, and keys. These connecting rods were, at their lower extremities, attached in similar manner to the crank-arms F F. These crank-arms turned (in their rotation round the centre G,) the little spur-wheels shown in the plate, and these spur-wheels acted together on the wheel H, which was firmly fixed on the driving spur-wheel. The rotation of this spur-wheel A is easily traced—tooth after tooth imbeds itself in the cavities of the toothed rail, and a hauling forward is the consequence.

The use of two engines (I mean of two cylinders and two pistons,) is, that where one piston (as in the case of the piston in C,) is just finishing its upward motion, to go down, and inclined to falter, the piston in B is in full play upwards, and both being connected, the faltering of the one, or tendency thereto, is corrected by the other.

The rack-rail was only on one side of the way. The boiler was placed and rested on four bearing wheels. J is the fire-door, from which a hollow tube (containing the furnace) goes through the boiler from end to end. K is the chimney. L is the waste steam-pipe, through which the steam is puffed off.

Messrs. William and Edward Chapman took out a patent in 1812, in which they specified the machine, Plate IV. figure 1.—The weight was distributed on eight points instead of only four, which, on a plate railway, or weak rail-road, was an advantage. The beam A, and its corresponding piston B, in the upward and downward motion on the fulcrum C (a fixed point), worked the connecting rod D, which was attached to the crank-arm E. The revolutions of this crank-arm were attended by corresponding revolutions of the toothed wheel F, which was on the same centre. And the drawing exhibits the working of F into G, and from thence to the spindle or axle of each pair of wheels.

Mr. Brunton, of Butterly iron-works, seeing the difficulty of others, struck out a new plan altogether, by which he arrived at a substitute for horses' legs. The piston rod A of the engine, Plate V. fig. 1, in its outward motion, forces out the leg and foot B, which pushes behind; at the same time, the alternate motion of a horizontal toothed wheel C above the boiler, works in a rack on the rod D, and thus pulls in the leg E. When the piston rod A travels back, the leg B is lifted back, and the same returning stroke of the engine forces out the leg E in its turn, by means of the toothed wheel above[1].

A lamentable accident from the cast-iron boiler stayed Mr. Brunton's exertions. This was a perfect mode for avoiding loss of steam-power by the slipping of the wheels. Mr. Brunton, however, fully proved the capabilities of such a locomotive engine with legs, both at Butterly and at the Crick lime-works.

At Killingworth colliery, in 1814 and 1815, Mr. George Stevenson constructed several engines, of one of which a side and end view is given in Plate VI. There were two cylinders, and the motion was given to the wheels in a manner similar to Trevethick's engine (Plate II.) But here Mr. Stevenson obtains the friction of four wheels at the same time; and the pistons in A and B work simultaneously, the front and hind wheels which they act upon, being connected by their axles, on which there is an endless chain C working on D D. The revolutions of the axles of the wheels cause the valve connexions E E E E, to be worked by the eccentric F, and its fellow eccentric. The pump G is worked by the up and down stroke of the piston rod.—H, the fire-door. J, the ash-pit. K, the chimney. The fire-place and flue being through the inside of the boiler, and surrounded by water. L.L. are cylinders, of which there are four. In these, four pistons work, and the pressure of the steam on their upper side forms a spring of the best kind, to preserve the engine from concussions.

This was the most perfect rail-road engine at work until 1830, when Messrs. Stevenson and Co. produced engines on the Liverpool and Manchester rail-way, which have completely eclipsed Mr. S.'s former works.

I shall not attempt any farther or more minute description of rail-road engines, but refer my readers to the second edition of a treatise on rail-roads by Mr. Wood. The present work is more immediately intended to relate to steam-carriages without rail-roads, although a short description of Mr. Stevenson's new boiler, and a plate showing one of his new engines, appear hereafter.

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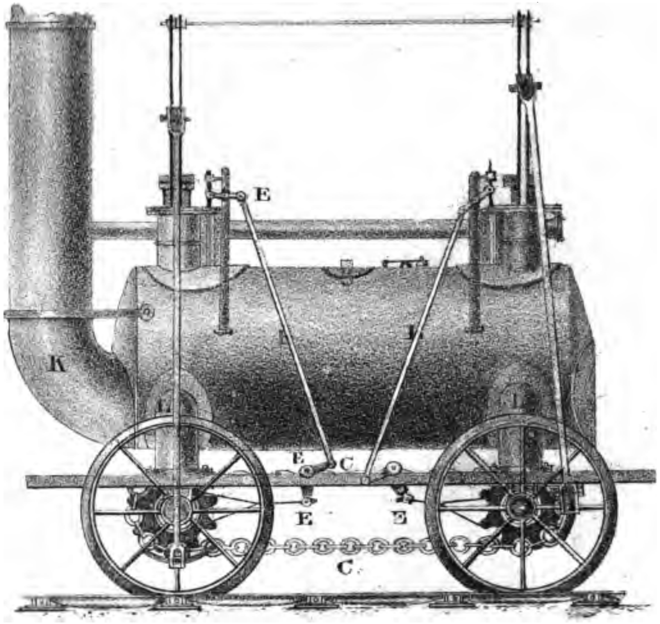
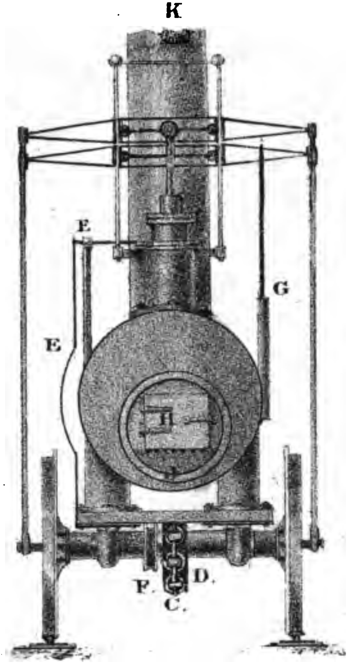
[1] Mr. Brunton has politely lent me a much more perfect drawing of his engine, wherein the lifting of the feet is more distinctly exhibited; but I preferred this drawing, because the legs are seen so clearly, which is the prominent feature.

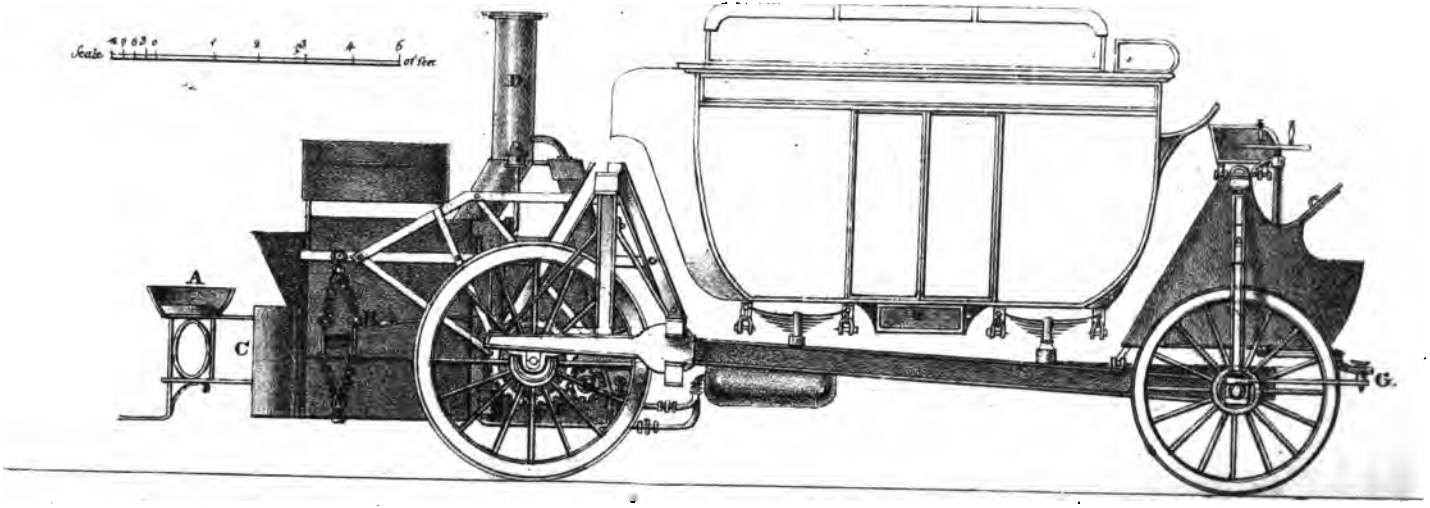
Plate 6.





A Gordon del^{t} et lith.

Plate 7.



A Gordon del.t et Lith: 146. Strand.

It is certainly very difficult to account for the long delay in the adaptation of a steam-carriage to a common turnpike-road. Engineers seem to have been shut up to the belief that it was impossible. It may be their very limited knowledge of the nature of a locomotive engine, and its operation precluded speculation as to this more extensive application; in much the same way as the limited knowledge of steam-boats in 1814 retarded, for so long a time, steam navigation on the ocean.

On a rail-way, the slight adhesion of the surface of the wheels to the rail was inadequate to propel the locomotive engine up any considerable ascent. This difficulty seems to have engendered the notion,—a notion scarcely yet removed, though proved to be absurd by a host of facts,—that a steam-carriage could never ascend a hill of even moderate acclivity.

When inventors turned their attention to common roads, every one of them seems to have resolved that the boilers then in use on a rail-way could not be adopted on a common road. Therefore, light boilers, or boilers holding but a small quantity of water, were resorted to as the first requisite. Light boilers were now invented in abundance. Scheme upon scheme, and patent after patent, in rapid succession, appeared canvassing for public approbation. Out of the abundance, three or four only were happy hits; and these few have been gradually working their way into general use.

Mr. Julius Griffith, in 1821, had a steam-carriage constructed by Messrs. Bramah and Sons, the external appearance of which is seen in Plate VII. It was intended to work on a good turnpike-road. Many experiments were made with it in Messrs. Bramah's yard, where it was to be seen for three or four years afterwards.

A, seat for the engineer. B, boiler. C, fire-door. D, the chimney. The engines worked on the spindle of E, which, working into F, turned the wheels, and the carriage advanced, being guided by a contrivance for that purpose at G. A drawing of the arrangement of pipes in this boiler will be found on Plate XI. fig. 1. H, the fire-place; the smoke and heated air passing through among the pipes J J J, in the direction of the arrows, and thence to the chimney. The horizontal pipes J J J, were 1½ inch diameter and 2 feet long, fastened by flaunches at each end, to the vertical boxes K K, which were the means for the hot water and the steam to ascend, and for the cold water to descend. Only six pipes and two vertical boxes are shown at this end of the boiler, but similar rows of pipes, and their vertical boxes, were placed behind these, making 114 tubes in all. Above the whole, the three chambers L L L were placed as steam-room, and from them the engines were supplied with steam.

These tubes would not always contain the water, and when empty, got so heated, that no force-pump could inject the water: on this account the invention was dropped. The steam, as it was generated in the horizontal pipes, passed along to the vertical pipes, from thence to the steam-chambers on the top of all, and from thence to the engines.

There is no doubt the failure is to be attributed solely to the boiler. The engines, pumps, and connexions, were all in the best style of mechanical execution; and had Mr. Griffith's boiler been of such a kind as to generate regularly the required quantity of steam, a perfect steam-carriage must have been the consequence.

This observation leads me to a remark, applicable in almost all cases, though perhaps not in this, that much money has been expended, and an age of time lost, on the one hand by steam-carriage projectors (for common roads) adhering too closely to their own views, and rejecting counsel; and from the prejudice of experienced engineers on the other.

When engineers of known ingenuity and experience are applied to, their advice should have every weight with the projector.

Mr. Farey says, in allusion to steam-carriages of the present day:—(Report, p. 44, 45.)

> "The general question of farther improvements in steam-coaches depends upon the general mechanical skill and judgment of the mechanicians who turn their attention to the subject, and the peculiar experience they may acquire in this particular branch of mechanics." * * * * *
>
> "You do not consider the inconveniences of the present steam-coaches to be inseparable from the invention?"—"Certainly not; but I do not think that any of the individuals at present engaged in the pursuit are the most competent persons who could be chosen to overcome the remaining difficulties, being inventors, who have almost completed their parts of the task, and not experienced practical engineers, into whose hands the affair of building the next steam-coaches ought now to pass, under the general direction and advice of those inventors; if the building of steam-coaches is continued in their hands, they will only advance towards perfection of proportion and execution by slow degrees, as the patentees acquire that general skill as engineers and mechanists which is already possessed by professional engineers."

"You think that the machinery may be improved by better mechanists?"—"I have not the least doubt of it; and yet those mechanists are not the proper men of genius to have invented what has been hitherto done by the patentees."

In 1822, the late Mr. David Gordon, the inventor of the portable gas-lamp and the pneumatic apparatus, required in the compression, took out a patent for improvements in wheel carriages, part of which he specified to be propelled or drawn by elementary power. Plate V. fig. 2. represents a side elevation of this machine. A, the high-pressure steam-engine, made after the pattern of Mr. Trevethick's, and having the wheels made with teeth, worked into a rack in the interior of B. B, the large rolling drum, about nine feet in diameter, and five feet from end to end. In the inside of this there was an iron rack, on which the toothed-wheels of A worked. By this arrangement the steam-engine, urged forward by its steam, climbed up the interior of the drum, as a turnspit dog or squirrel would do in its daily labours; and the large drum rolling onward impelled the carriage.

I have lately been informed by Mr. Samuel Moyle, that at a subsequent date he used a large drum of this kind with great advantage for the transport of heavy goods over a swamp in South America. Having a quantity of plate-iron, which was too heavy to carry over otherwise, he riveted the plates together into the shape of a large cylinder, and carried other heavy goods in the inside of it. As the party advanced, this huge machine rolled with them. Afterwards the rivets were cut off, and the iron-plates, arrived at their destination, were put to other use.

In 1824, Mr. David Gordon took out another patent for an arrangement of machinery, by which an action similar to horses' feet could be obtained. This was effected by six hollow iron-legs, 1, 2, 3, 4, 5, 6, (Plate VIII.) at the lower extremity of each of which there were feet to push upon the ground. These six legs were connected by brasses, straps, and keys, *a a*, to the outer journals of the eight throw crank C C, &c. This crank was propelled by the pair of steam-engines D D, on the same shaft. This crank pushed out the legs backwards, and the carriage run forward. The legs were thus projected in succession: 2 following 1, and 3 following 2; then 4, 5, and 6, follow in the same course, each pushing the ground, for the distance of from *b* to *b*. By following this motion of the feet, it will be seen that they trotted round the oval, which a line drawn through the figures would describe. This oval was formed of two diameters, one of the large crank C, and the other of the small crank at *c*. The little crank lifted the feet off the ground as they finished their work. The crank-shafts C and *c* were connected by a small spindle F, on which, and on the two crank-shafts, were mitre wheels; so that a large crank and a small crank always revolved simultaneously and parallel to each other. The object was to substitute propellers instead of the driving-wheels; for that purpose he had propelling legs in the middle of the locomotive engine, similar to horses' legs and feet, working through the bottom of the body of the carriage against the ground, thus propelling the carriage onward.

In the fore part of the carriage, and centrically between the driving and lifting-cranks of the propellers, are placed the steam-engines, (see figure 2); these consist of two brass cylinders, in a horizontal position, which vibrate upon trunnions; and the latter being hollow, form the induction and eduction passages for the steam. The piston-rods of the cylinders are attached to two distinct throws of the driving-crank, placed at right angles with respect to each other, so that the vibration of the cylinders admits of the piston-rods following the revolution of the crank. Thus there are eight throws to the driving-crank; viz. two for the cylinders, and six for the propellers, turning upon the same axis, but upon nine distinct bearings (two to each throw) on the framework of the carriage. The force of the steam-engines, and the rotary motion of the driving-crank is communicated to the lifting-crank, by means of connecting rods on the outside of the carriage; and the arrangement is such, that the throws of each respective crank are always parallel to each other.

Figure 2 represents a plan of the machinery in the fore part of the carriage; *k k* are the eight throws of the driving-crank; the axis of which turns in plummer-blocks, fixed on the wooden frame of the carriage; *l l* the six throws of the lifting crank, the extremities of whose axis are connected to the ends of the axis of the driving-crank by means of the rods *f f*; 1, 2, 3, 4, 5, 6, are the feet of the propellers connected by their rods to the driving crank; and *s s* are the double straps by which the feet of the propellers are attached to the lifting crank. The steam is brought on from the boiler (situated at the back part of the carriage) by the pipe *r r*, and passing through a breeches-piece, enters the cylinders *d d* by the hollow trunnions, on which they vibrate:

Fig: 1.

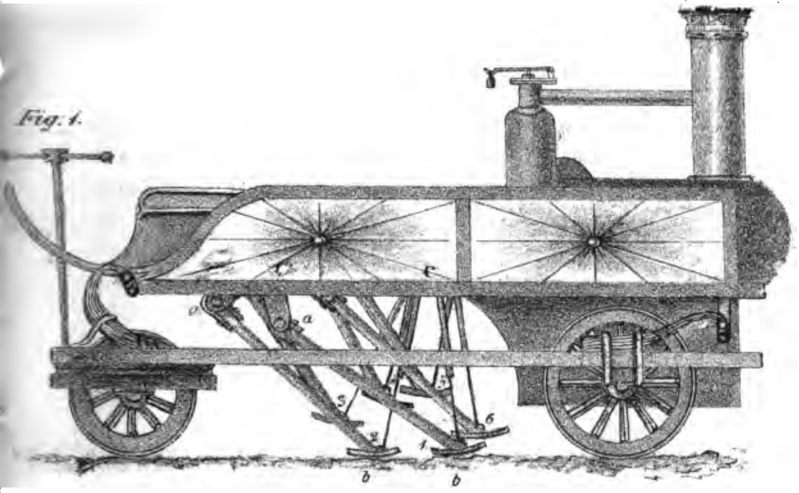


Fig: 3.

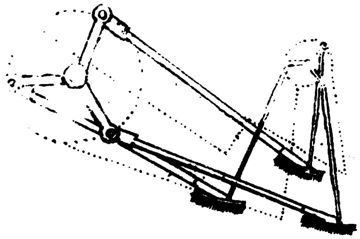
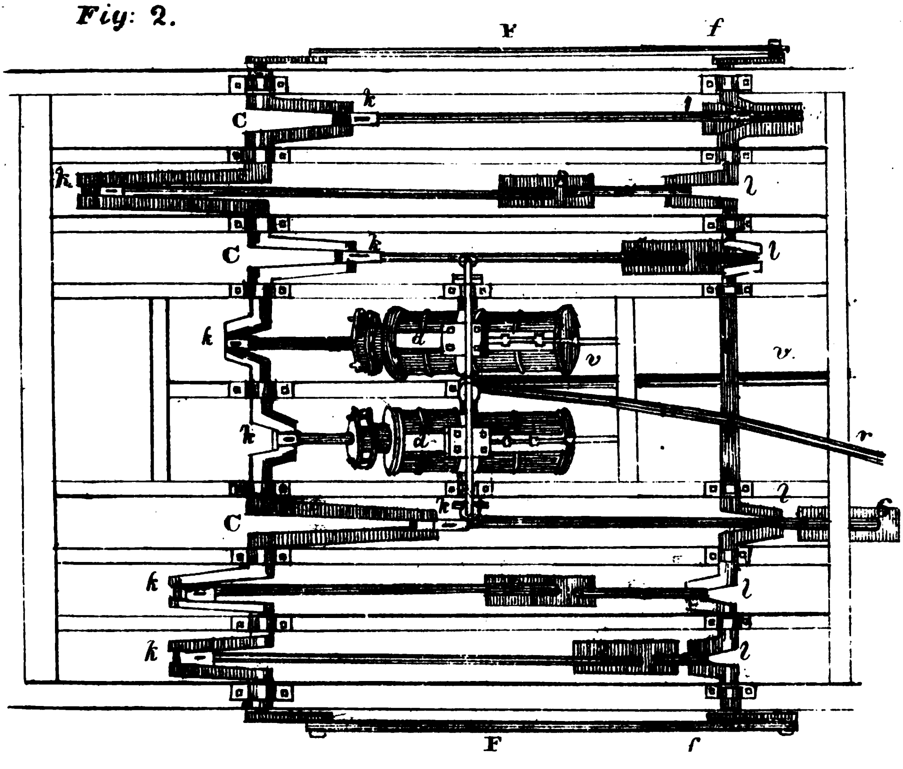


Fig: 2.



the steam passes out of each cylinder through the opposite trunnions, and escapes by the pipe *v*.

It will be perceived that there are three throws to the driving crank on each side of the carriage; on one side they radiate from the axis at 120 degrees apart; they are the same on the opposite side, but so posited as to come intermediate with the throws of the former; that is, when the crank is viewed end-ways all the six throws appear uniformly at *sixty* degrees apart. This arrangement is essential to the proper action of the propellers, which is, that when a propeller on *one* side has been thrust out, another propeller on the opposite side shall succeed its movement, instead of an adjoining one.

The method of constructing this crank is very different to the laborious process generally adopted, while it is much better. Each arm of the crank is made separately, and with eyes to receive the outer and inner journals; these eyes are chucked in the lathe, and faced to receive the journals, which are also turned in the lathe: the journals being then put into the arms of the crank, when the eyes are expanded by heat, they are pinned and rivetted. To prevent the feet bounding off the road, without taking hold and pushing the carriage onward, it was found necessary to use lifting rods. These rods were hollow, and had a small solid rod in their interior, which was pressed out by a spiral spring in the hollow rod; so that these connecting rods, (the lifting apparatus,) were lengthened when the feet got into a hollow, and shortened if the feet got on a stone or other little eminence betwixt the tracks of the wheels.

Figure 3 exhibits three of the driving and three of the lifting cranks, with their corresponding three propellers.

After attempting to make a light boiler, which he felt to be a desideratum, Mr. Gordon applied to Mr. Gurney, and obtained one of his boilers hereafter described. This boiler was situated in the hind part of the body.

The whole was supported by three wheels, one in front and two behind; each wheel being supported on both the outer and inner side, and having its own axle. There was thus no axletree extending from side to side, and the well, or lower part of the body, was made of a large size, so as to keep the centre of gravity near the ground.

In my evidence before the Committee of the House of Commons, it will be seen (Report, p. 74.) that both of these are for the present given up, because—

> "Mr. Gurney's progress in 1826 and 1827, showed clearly that this arrangement was not necessary in every case, but that one of the wheels of the carriage, when attached to the steam-engine, had a sufficient hold of the ground to give progressing motion to the carriage, without using propellers; and the introduction of that invention has subsequently been given up by me in consequence."
>
> "Have both the plans you have given in been given up?"—"Both; it was an expensive business to proceed with them. Mr. Gurney had made such great advances, that it would have been throwing away money, I think, to have gone on further with them. I found that the propelling feet, shown in the middle of the engine, do more injury to the roads than the propelling wheels."

Still, there are many situations and seasons in which a steam-carriage using its power in this manner may be highly useful. A road covered with ice, a sandy soil, or a very soft soil, such as a ploughed field, when steam-power is applied to the plough or harrow. Nor is this latter case so remote. When steam-power is once established on the roads, it will not be long before it reach the fields.

In November, 1825, Messrs. John and Samuel Seaward, of the City Canal Iron-works, obtained a patent, under which their claim was for "the propelling locomotive engines, vehicles, and other carriages, by means of a wheel or wheels connected either by a swinging frame or frames to the crank-shaft of a steam-engine, or other moving power, or working in circular grooves, so that it or they may rise or fall to accommodate themselves to the roughness or unevenness of the ground, but supporting no part of the weight of the said engine, such weight being entirely supported by separate wheels."

The locomotive engine, A A, Plate III. fig. 2. was placed on two pair of wheels, B B; C is the crank-shaft of a steam-engine within the body of the machine; to the shaft C is attached the swinging-frame D, with a propeller, E, turning on its axis, G, at the vibrating end of the swinging-frame. The steam-engine was upon the springs F F, so that the machine might travel on rough roads.

In 1829, Sir James Anderson and Mr. James constructed a steam-carriage under the patents obtained by the latter gentleman in 1824 and 1825. The striking feature of this invention was the boiler, and the high pressure these gentlemen are said to have worked with. I have seen their locomotive engine, but not at work; and as their pressure was then said to be 200 lbs. *upon the piston!* it may be as well to transcribe from the published account in the Mechanic's Magazine, as much as will form the link of history.

"They formed the boiler by combining a series of annular tubes or ring-formed chambers, which chambers communicate with each other by apertures running through the whole series, in order to allow the water and the steam to flow freely from end to end of the cylindrical vessel, so formed by the combined tubes or chambers; and which vessel has a furnace adapted within it for the purpose of heating the water and the steam contained in the annular tubes or chambers. That is to say, (to speak more plainly), a series of hollow rings or annular tubes, (made, we understand, of the best iron, and three-fourths of an inch in diameter), each communicating with the other, are arranged spiral-wise and circularly, so as to form a cylinder of rings; and within this cylinder a furnace is inserted upon suitable bearings, and capable of sliding in and out, which, with its flue, occupies the whole interior of the cylinder. The rings or tubes form a continuous length of 430 feet 5 inches. They are filled with water rather more than half way up. The flame and heated vapour arising from the furnace, in passing from thence to the chimney, enters the jacket, (or outer casing of the cylinder of rings), and embraces the external surface of the tubes.—By these means the water in the lower parts of the vessel (lower portion of the tubing) is made to boil, and the steam generating therefrom rising into the upper, becomes greatly increased in its elastic force by the immediate action of the fire. The steam is kept confined in this upper portion of the tubing till the pressure reaches any desired point, when it is let off by an eduction-pipe into the working cylinder."

The cylinders were four in number, and placed horizontally between the hind wheels. The speed of the carriage was at the rate of nearly fifteen miles in the hour. But the structure of the boiler leads us to doubt whether the steam could be regularly kept up, and, consequently, to doubt if the carriage could ever travel fifteen miles *in the hour*. Excepting that there were no sharp corners in this boiler, it does not appear to offer any advantage beyond Mr. Griffith's. Hence it could not be depended on for permanent and steady work.

Messrs. Hill and Burstall obtained a patent in August, 1826, for improvements in the machinery for propelling locomotive carriages. One constructed on their patent was exhibited in Leith and in Edinburgh, and also in front of Bethlehem Hospital, London, in 1827; at which latter place we saw and examined it in successful operation. This carriage, however, was soon abandoned; and we will, therefore, refer our readers to the Repertory of Patent Inventions for February, 1828, where an account of it will be found.

Inventors seemed now to have received a new impulse. Their multifarious plans, good and bad, burst upon us in quick succession; some to make a noise and bustle for a time; and some merely to twinkle from their obscurity, and vanish without leaving even a remembrance behind.

Perhaps many valuable inventions have not been made public. At the same time there are many inventions in locomotion, which, at this early stage of history, are so little known to us that we cannot give an account of them.

Mr. Goldsworthy Gurney, in 1825, produced a steam-carriage; and his improvements upon it led to his successful introduction of steam-carriages on turnpike-roads, as an established and regular conveyance for the public betwixt Gloucester and Cheltenham, in February, 1831.

Mr. Gurney's patent boiler, as now used, is exhibited in Plate X., in which, figure 1 is the front elevation; figure 2 the side elevation of the boiler without its external casing; figure 3 the plan. The boiler has been variously modified, but this is a view of the most perfect mode which Mr. G. has tried.

Mr. Gurney also obtained a patent for a locomotive carriage in 1825, which is described in the Repertory of Arts in the following manner.

" In this apparatus, the carriage has two straight perches parallel to each other, a small distance asunder, which have grooves or hollow channels made at their lower side, for the greater part of their length; in these channels oblong blocks are placed, furnished with vertical and horizontal anti-friction rollers, to facilitate their motion forwards and backwards, and from their sides slips project that run in grooves made at the sides of the channels, and which serve to prevent the blocks from falling out, if the carriage should be raised; from the bottom of these moveable blocks, legs or crutches of metal descend to the ground, by which the carriage is impelled; these legs have a flexure at their tops, towards the head of the carriage, and another at their heels, in the contrary direction, to which a curved shoeing is fastened, to keep them from being worn; they are attached to the blocks merely by a vertical bolt that passes through the front of the upper flexure a small distance, where it is terminated by a nut and screw; between which nut and the flexure a spiral spring is placed, which, by its yielding, enables the heel to pass better over small obstacles, and again draws the head up to its proper position: these legs may be turned round on the bolts at their heads, when it is required to move the carriage in a reversed direction.

"The carriage is impelled by these legs being drawn alternately forward, and pressed backwards by a steam-engine, that acts on the blocks in the following manner; the main cylinder of the engine is placed horizontally, and the head of its piston-rod is sustained by a piece of metal, placed in a similar position, on which a vertical anti-friction roller, attached to it, runs; one end of which piece rests on the bed of the cylinder, while its other extremity is fastened to the back of an upright bar, that ascends from the front of the carriage (to which it is also connected at each side by an oblique brace) to some distance above the level of the cylinder, bending forward at the same time; and from whose head two moveable levers descend to a line with the blocks of the impellers; two other levers, which are jointed to the front of the carriage, midway between the cylinder and the upright bar, on the contrary, ascend, a little way above the top of the cylinder, and are there connected to the descending levers by horizontal rods, which are jointed to them at their different extremities; the lower ends of the descending levers are, in their turn, connected by similar horizontal rods to the impelling blocks, so that when the first, or ascending levers, are moved back, and forwards, this motion will be communicated to the blocks by the other levers, and the horizontal rods mentioned; and these two ascending levers are made to have this motion by one of them being connected by a joint with the head of the piston-rod, from which chains pass round horizontal pulleys (that lay in mortices made in the piece of metal on which the antifriction roller of the piston-rod runs) on to the other ascending lever; so that, when the piston-rod draws that one back, the other is drawn forward by the chain, and the contrary, when the other impels it forwards. These two pairs of levers, thus placed, permit the speed of the carriage to be increased or diminished, by shifting the horizontal rods that connect them to higher or lower positions on them, for which purpose several holes are bored through them, at regular intervals as under."

In his first experiment he ascended Windmill-hill, near Kilburn; but being then of the prevailing opinion that the friction of the wheel was not sufficient to impel the carriage up acclivities, he used the legs, or propellers. This application of levers was inconvenient and heavy, and after much thought and experiment, a combination of these levers and the wheels was resorted to. It was so arranged, that when the wheels should slip, the levers should come into action. A trip by steam, betwixt London and Edgware, was effected by this arrangement. The levers were subsequently entirely abandoned, the wheel being found not only to be sufficient for impelling the carriage, but also to allow considerable free traction.

On the 15th September, 1830, the Liverpool and Manchester rail-way was opened for public traffic, with eight of Messrs. Stevenson and Co.'s locomotive-engines; the Northumbrian led the procession on that occasion. Plate V, fig. 3 and 4, represent this engine; A, the boiler; B, the situation of the fire; from whence a number of small tubes convey the heat through the water to the chimney C. D D, the cylinders of the engines; E E, the valves' motion; F, one of the piston rods. The boiler and flues are of copper instead of iron. A tube from the waste steam-pipe to the bottom of the furnace enables the engineer, by turning a cock, to pass the superfluous steam through the fire in aid of the combustion. The boilers of all of Mr. Stevenson's engines are not tubular, but have tubular flues; that is to say "a series of straight tubes of equal diameters enclosed in one general casing, and immersed in water." This engine has 150 of these tubular flues, and weighs 6 tons 3 cwt.

On the 23d November, 1830, the distance betwixt Manchester and Liverpool was travelled by one of Mr. Stevenson's engines, the Planet, in sixty minutes[1]! of which two minutes were taken

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[1] For the sake *of comparison* I quote two advertisements; the first was in 1678, and the other in 1765.

Mr. William Hume, merchant, Edinburgh, contracted with the magistrates of Glasgow, that he "should have in readiness a sufficient strong coach to run between Edinburgh and Glasgow, to be drawn by six able up in oiling and examining the machinery midway. No train of carriages was attached to the engine in this case, and only three persons were upon the engine.

Plate IV, fig. 2, represents an engine built by Messrs. Braithwaite and Erricsson for the same rail-road; A A, the boiler. The coke or other fuel was dropped through a double door near the top of the vertical part of the boiler. From top to bottom of this vertical part of the boiler there is a vertical tube passing, which is surrounded with water. At the lower part of the tube is the furnace—from the side passes the flue through which, in a serpentine descent, the heated air passes. The draft is got by means of a revolving fan at the upper part of the boiler. "The extent of surface exposed to the action of the heat by this arrangement is a great deal less than in other engines; and were the heat left to circulate as in other engines through the agency of what is commonly called atmospheric draught merely, there would probably be nothing gained in respect of the quantity of steam generated;" but the patentees used a strong draught of air obtained by their fan, and urged the fire to a great degree. Both the engines of Messrs. Stevenson and Co. and Messrs. Braithwaite and Erricsson produced the draught by exhaustion by mechanical means; the latter by a fan, and the former by the rapid discharge of a jet of steam up the chimney.

This elegant engine, however, could not do the required work, as I find recorded in the Institution of Engineers, that on the 17th and 18th February, 1831, trial had been made of these engines wherein they decidedly failed. The William the Fourth occupied two hours and a half betwixt Liverpool and Manchester. The Mars engine (Stevenson and Co.) overtook it on the way, and pushed it into Liverpool. The same engine drew five loaded waggons a distance of nine miles in one hour; it then fell off in speed, and ultimately had to transfer the load to the

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horses, to leave Glasgow ilk Monday morning, and return ilk Saturday night, God willing."

"A new post-coach, hung on steel springs, with four horses and two postillions, sets out from the Greyhound Inn, Market-place, Bath, and the George Inn, Drury-lane, London, every Monday, Wednesday, and Friday, at seven o'clock in the morning, and arrives at the above Inns on the following days at four in the evening. The coach stops all night at Andover, going and coming."

Dart engine: it completed the journey at length, after being three and a half hours on the way.

I also find recorded in the Institution of Engineers, that the Samson engine (Stevenson and Co.'s) on 25th February, 1831, started from Liverpool with thirty waggons, carrying 82½ tons of oats in twenty-three waggons; 24¾ tons of merchandize, and 1 ton weight of passengers (fifteen persons) in seven waggons= 108¼ tons. To which add 42¾ tons for the tares of the waggons, in all 151 tons. The engine was 8½ tons weight; the tender with coke and water 5 tons. With this enormous load, 164½ tons, the speed of the engine averaged twenty miles an hour on the level; but when the train came to the inclined plane the Samson only drew 62 tons, but with itself and tender 72½ tons. The inclination of the rails was 1 in 96. The two cylinders of this engine are fourteen inches diameter, and the stroke sixteen inches. The wheels are 4½ feet diameter, and are all four attached together. Effective pressure per square inch of the boiler thirty-five lbs.. By taking the average speed throughout, at thirteen miles an hour, the same work would have required seventy good horses.

It is not yet publicly known that these locomotive engines, powerful and swift as they are, must either be worked at a cheaper rate or abandoned; so at least I am well informed, of which more will appear in the following chapter.

In no part of the world has a good communication from place to place been more sought after than in the United States of America; yet there steam-carriages have not kept pace with steam boats. Many rail-ways are, however, in contemplation, and a rail-road of unexampled extent is now in the course of formation from Baltimore, across the Alleghany mountains, to the Ohio. Plate IX. fig. 1, exhibits a perspective elevation of an American locomotive rail-way carriage, the recent improvement of Mr. Howard. Fig. 2, a back view; figs. 3 and 4, part of the wheels, to illustrate more clearly their mode of action. To use the description of the Mechanic's Magazine, No. 328, the same letters of reference refer to the same parts in figures 1 and 2; and to make the peculiar improvements which Mr. Howard has here introduced the more easily recognized, his friction-wheels, and some of the minor details of steam apparatus, are omitted.

"The first desideratum which Mr. Howard has made it his

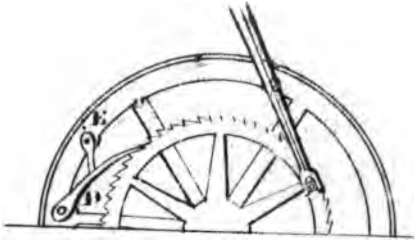


Fig. 3.

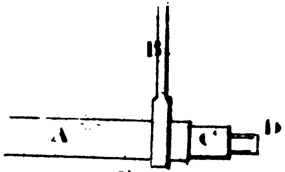


Fig. 4

Fig. 1

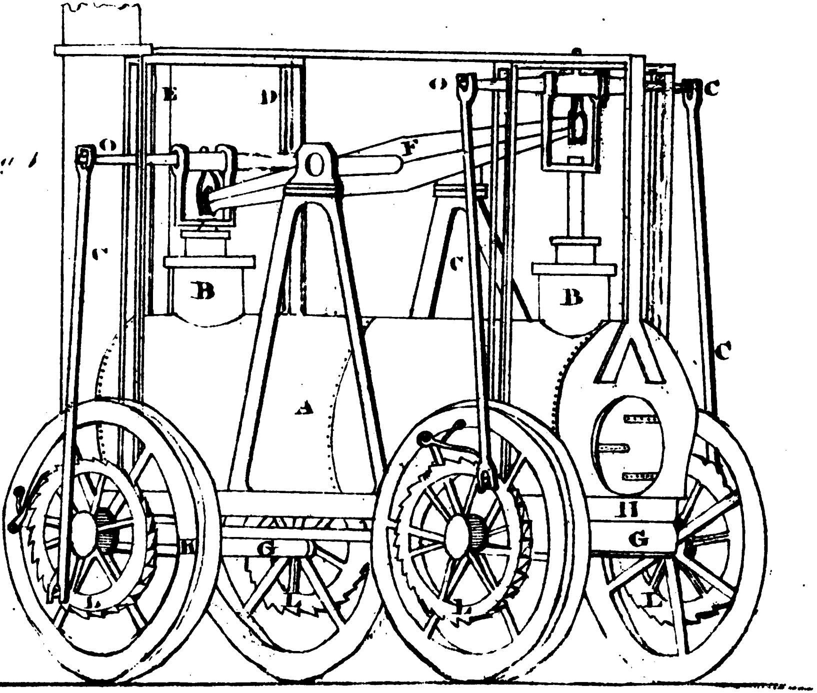
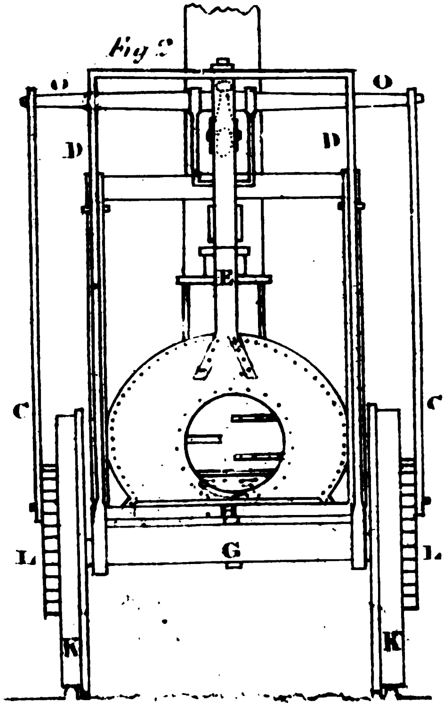


Fig. 2



study to accomplish in this engine, has been to render the axletrees capable of adapting themselves to the curve of the road, so that a perpendicular plane drawn through the centre of the axle may be normal to the curve. His arrangement for this purpose we shall give in his own words:—

" 'The usual beam, fastened by jaws to the axles, is divided in the centre, and a tooth and socket permits one end to play in the other. This contrivance, as shown in my improved rail-way carriage, obliges the hind wheels to follow in the track of the fore ones. Besides this, there is a beam extending from one axle to the other, and traversing on the centre of each, round a strong bolt. To this beam, the boiler, A, with the cylinders, B B, are attached. The boiler, indeed, may be made to answer the purpose of this beam, by placing it upon beds, H H, beneath which the axles, G G, move horizontally around centre bolts. At each side of the boiler, and attached to the axles, and moving with them, are perpendicular supports or guides, D D, with openings for the vertical motion of the ends of the shackle-bars, O O, of the piston-rods; each pair of supports, or guides, being connected at the top by an iron bar, in the centre of which is a bolt connecting it with an iron frame, E E, passing lengthwise from each extremity of the boiler to which it is fastened, and which keeps the supports, or guides, in their vertical position. This last bolt is directly over the bolt of the waggon-bed, as well as over the centre of the cylinders, so that when the axle moves horizontally around the waggon-bed bolt, the supports, or guides, moving with it, make the bar connecting the supports, and which is always parallel with the axle, revolve round the bolt in the frame above the boiler and cylinders, which are stationary; and the shackle-bar moving at the same time horizontally, with its guides, around the head of the piston-rod, which is constructed to allow of such motion, the horizontal motion of the axle does not interfere with the working of the engine. To preserve a uniformity of motion, a balance-beam, F, supported from the boiler-bed, is connected with the shackle-bar of each piston-rod, so as to allow of its vertical motion, and, at the same time, the horizontal motion occasioned by an alteration of the direction of the wheels. In this I claim as original the principle of making the shackle-bar traverse round the head of the piston-rod, and the means by which this is accomplished.'

"The next point to which Mr. Howard has directed his attention is the means of making the outer wheels go faster than the inner, which he accomplishes in this way:—

"The axle revolves as usual in rail-way waggons, and the carriage-wheels revolve likewise upon the axle; but at the extremity of the axle there is a ratchet-wheel, L, fastened, to the rim of which the connecting-rod, C, from the shackle-bar, is fastened, instead of to the carriage-wheel, K, as is customary. From the rim of the carriage-wheel there is a catch and spring, E D, fig. 3, striking the teeth of the ratchet-wheel, and uniting the two as one wheel, except when it becomes necessary that one carriage-wheel should, in describing a large circle, go faster than the other, or, in other words, faster than the axle and ratchet-wheel. The carriage-wheel then moving faster than the ratchet-wheel fastened to the axle, the spring and catch on the rim slide over the teeth of the ratchet-wheel, until a straight motion makes the catch hold the teeth again, or a reversed curve causes the opposite wheel to perform the same operation. So that the engine, notwithstanding the altered velocity of the wheels, still performs its motion with regularity; no change ever taking place in the velocity of the ratchet-wheels."

In fig. 3, A, is the carriage-wheel; D, the catch; E, the spring. In fig. 4, A, represents the axle; B, the supports or guides; C, the shoulder for the carriage-wheel; D, the octagon for the ratchet-wheel.

In October, 1827, Mr. Gurney obtained another patent for improvements in locomotive-engines, and in the apparatus connected therewith. Under this patent he worked with a steam-carriage resembling, in external appearance, the common stage-coach, the boiler being situated in the hind boot. In the fore boot a blower, like the revolving fans of a winnowing-machine, moved round horizontally in a close box, from which a tube conveyed the blast to the close ash-pit of the fire-place. The engines acted upon the cranks on the hind axle. "The hind wheels had sockets, or boxes, in their centres, like common wheels, so that either of them might be made to run loose on the axle when required; and they were fastened to the axle so as to turn round with it, at other times, by means of a round plate fitted on a hexagonal part at each end of the axle; and a similar plate being fastened to the nave of each wheel, close to the former, screw-

Plate 10.

Fig. 1.

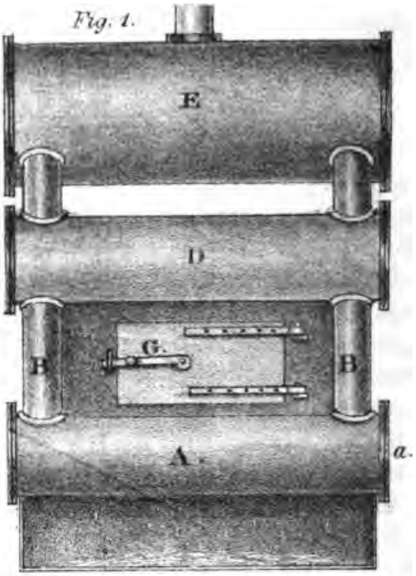


Fig. 2.

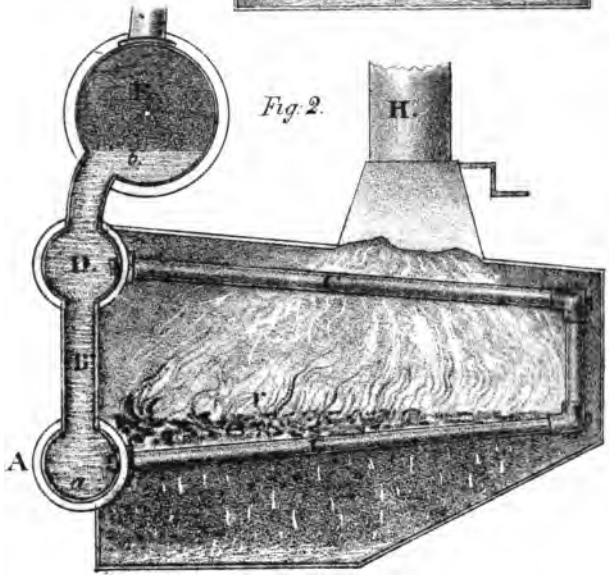
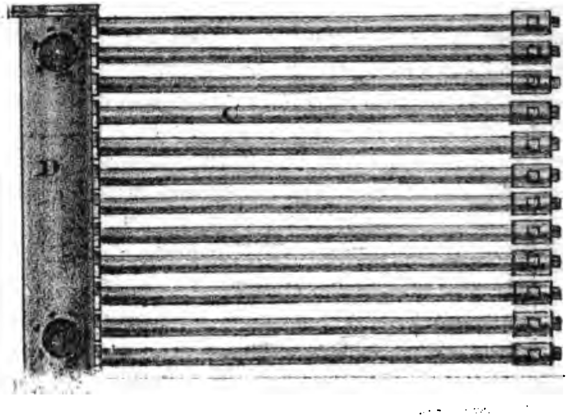


Fig. 3.



bolts passed between the two plates, and, secured with nuts, gave the desired connexion, which could again be withdrawn by removing the bolts."

The great advantage Mr. Gurney has over other inventors consists in his boiler, which it is now time to describe. There are other improvements, but this is the distinguishing feature of his steam-carriages. Plate X, fig. 2, shows a section of one of these boilers; A, the point at which the water is pumped into the boiler; B, the water-level in the separater, E. It will be observed, that A B C D. (figs. 1, 2, and 3,) are all full of water. The fire is made at F, and plays around and through the tubes D. The hotter particles of water occasion a continuous flow from A, through C, to D. When they arrive at D, their colder particles descend through B, and again are drawn through the tubes C. The tubes C, it will be seen by their inclination, always offer an ascent for the hotter particles and for the steam. By this arrangement, the circulation is constant and complete. The steam is rapidly given off at E, where it is ready for the engine. This chamber, E, is sometimes placed vertically, instead of being placed horizontally. Sometimes there are two of these steam-chambers E, connected together, and to the engine, by what is termed a breeches-piece. G is the fire-door, H the flue.

In all of his last coaches, the patentee has discontinued a blast for urging the fire, and has used the waste steam to occasion a draft. This is effected by blowing the waste steam by several small jets upwards into the lower part of the chimney at J. The increase or decrease of draught is regulated by the size of the aperture through which it is ejected. A very perfect draught is thus obtained, and the fire can be enlivened or damped according to the required speed of the engine. With a boiler containing so small a quantity of water, and so large a proportion of heating surface, the facility of lessening or increasing the heat, and consequently the power of the steam, is very great. And this facility is highly important for economising fuel, and for the quick and certain management of the steam-carriage on hilly or crowded roads.

In February, 1831, Mr. Gurney having completed three steam-carriages for Sir Charles Dance, that gentlemen commenced running one regularly on the road betwixt Gloucester and Cheltenham, and continued so to do constantly and successfully for four months, until he (disgusted with the opposition) withdrew his coaches. So strongly did the opposition press upon steam-carriages, that Mr. Gurney found it necessary to petition the House of Commons. Several bills had hastily been passed through Parliament, laying prohibitory tolls on steam-carriages, in some cases amounting even to 2*l.* for each time the steamer should pass. Such bills may have originated with agriculturists, who had not weighed the advantages; or may have originated in a notion that a "steam-carriage was a steam-boat on wheels," or partly in the *stable* habits of some country gentlemen, who love no change. Be that as it may, an investigation took place, which now causes this science to shine forth with increased lustre.

Mr. Goldsworthy Gurney examined. (See Report of the Committee, page 17.)

"Are you the proprietor of a steam-carriage used on public roads?"—"Not the proprietor; I am the patentee."

"On what roads have you commenced running such carriages?"—"I have commenced on several roads. The first road I commenced was Edgware, then Stanmore; I ran there for a short time only, principally experimentally; then to Barnet, to Edgware, to Finchley, and other places. I also ran a carriage on my own account to Bath and back; that was only one journey—an experimental journey. Since that, they have been running as public stages, principally between Gloucester and Cheltenham."

"For what period?"—"Since February last. They were stopped about three weeks, in consequence of an accident to one of the axletrees; they were to begin again about this time."

"Have you been yourself on these carriages while they have been running?"—"Yes; in the first instance, I almost always accompanied the carriage."

"State in detail the progress which you have made in bringing these carriages to their present improved state?"—"In the year 1825, it was a very prevalent opinion that the bite or friction of the power to the ground was not sufficient to propel the carriage along a common road, particularly up hill; it was thought that the wheel would turn round, and the carriage not proceed. With that view, the apparatus which I call feet or propellers were proposed to be used. I soon found by experience, in numerous experiments, that the propellers were rarely or never wanted; and I then applied the power immediately to the two hind wheels, through a crank, in the common mode of a steam-boat, the propellers being also fixed, but travelling slower than the wheels, were brought into action if the wheels slipped, which it was thought would be the case in difficult situations. This carriage went up Highgate Hill, in 1826, and to Edgeware, also to Stanmore, and went up Stanmore Hill, and Brockley Hill, near Stanmore, and against all those hills the wheels never turned, and the legs never came into action. After these experiments, the legs or propellers were entirely removed, and from further experiment it was found, by a peculiar application of the steam, (namely, by 'wiredrawing,') that the bite of one of the hind wheels was sufficient for all common purposes. If the steam was let on suddenly, the wheel would turn round, and the carriage not go forward; but when wire-drawn, one wheel was found sufficient. By this arrangement, also, the carriage was guided more accurately and more easily. The second wheel was applied by uniting it with the crank at any time, if one was found insufficient."

"In general, were the wheels connected together, or had they an independent motion?"—"Always one was attached to the axle; they had no independent motion; on the arm or carrier of the wheel (which is a part of the axle), and can be attached to the wheel at pleasure by a bolt, making the wheel also in that case part of the axle; this carriage, I should observe, ran to Barnet, and went up all the hills to Barnet, in 1827, with one wheel only attached to the axle, and was run for about eighteen months experimentally in the neighbourhood of London; from these experiments showing that one wheel was sufficient to propel the carriage, and the carriage being at the same time reduced two-thirds in weight, it was thought desirable to draw another carriage, instead of to carry on the same. This carriage went to Bath, and over all the hills between Cranford Bridge and Bath, and returned with only one wheel attached to the axle; the other carrier by means of attachment having broken in the first onset, and not having been repaired until after its return; the carriage was also injured slightly at Melksham, in consequence of a riot there; we waited about two days at Bath to get this injury repaired, and returned from Melksham to Cranford Bridge in ten hours, a distance of eighty-four miles, including stoppages."

"Have you made any alteration in the formation of the boilers since 1825?"—"We have altered and changed in the mechanism only; the principle has been invariably adhered to; the present carriage is deprived of its chimney and a variety of other disagreeables about the carriage."

"Has your principle with respect to all remained the same?"—"Precisely the same."

"How far have you improved the formation of your working carriage as to weight?"—"The weight was a principal objection to the practical application of the carriage; the first carriage of a given power weighed four tons; this was objectionable on account of its weight, which was severely felt in consequence of its effect on the roads. I thought it would injure the roads, which injury would produce a toll that would perhaps injure the economy of it: one weighed four tons; another weighed three tons, with the same power; another two tons, with the same power; the present carriages building will not weigh more than 35 cwt. with the same power."

"What does the carriage which runs between Gloucester and Cheltenham weigh?"—"By a letter from a magistrate, now produced, it is stated to weigh nearly three tons; it ought to weigh only 45 cwt.; if it weighs three tons, there is extra weight of which I know nothing; this which I produce a sketch of weighs 35 cwt. and it has the same power. Those carriages at Gloucester were built principally under the superintendence of another person."

"When you state the weight of 35 cwt. you mean the weight of the travelling-carriage alone, without the weight of the passengers, or the weight of fuel or water?"—"Yes, just so; I think it is possible to reduce the weight considerably as improvements go on; I have a carriage now building which I do not expect will weigh above five cwt., which I expect to do the work of about one horse, and carry two or three people; speed is a particular object, and it is not intended to carry any thing more than light parcels."

"Into what stages would you divide your journies most conveniently?"—"I think about seven miles."

"What weight of fuel and water would you lay in for such a stage?"—"The fuel and water will be in proportion to the size and power of the carriage."

"For a machine weighing 35 cwt. what weight of fuel and water would you require?"—"Three bushels and a half of coke is the quantity we take to supply this distance, and the first charge two bushels; the first charge always remaining, it decreases of course down to the first charge, and taking the mean it will be 3¾. The weight of water at present I think is about 10 gallons a mile which is consumed, that would be 70 gallons, a gallon weighing about 10 lbs. making 700 lbs., the mean of this will give the quantity. If the roads are good it does not take so much, we can do with almost half the quantity; if the roads are bad we must take the whole quantity, and the mean will be 350 lbs."

"Will you state the progressive alterations you have made in the diameter of your wheel, and the breadth of the tire?"—"The diameter of the wheel has generally been the same, about five feet."

"What difference is there between the fore and hind wheels?"—"About the proportion of an ordinary carriage."

"The power is attached to the hind wheels?"—"To the hind wheels only."

"Do the wheels follow in the same track?"—"That is a matter of option."

"The Committee understand that they do not in that which travels between Cheltenham and Gloucester?"—"Perhaps that is the case there; it is a matter of convenience in some experiments; I have built them with three wheels only, one wheel in front, and in some with six wheels, my present carriage has only four."

"Do the hind wheels of your present carriage follow in the same track with the fore wheels?"—"Yes; those carriages now building will do so; the hind wheels will be nearer to each other than in many others."

"What diameter do you propose to make the propelling wheels of your new carriages?"—"I propose to have them about five feet; I would observe, that by taking a wheel of five feet diameter off the axle, and putting on one of two feet six, the engine would be multiplied double in its power, and lose of course one half in speed; in some cases it may be desirable to do so if the carriages are used for general purposes; for speed and dragging of heavy weights alternately, larger or smaller wheels may be put to meet circumstances as they occur."

"From the experiments you have made, with a view to proportion the diameter of the wheels with the weight to be drawn and the velocity required, what diameter of propelling wheel do you think will be generally used?"—"Five feet; the piston of the engine should not travel more than two miles and a half per hour; therefore we may multiply from this rate to any speed we please."

"What is the breadth of the tire of your present wheel?"—"None less than two inches; but in late experiments we found a wide tire more desirable than a narrow one, and we have increased it to about three inches and a half in width; we found that there is no increase of power necessary with a wide wheel, but I think on the contrary rather less; we have not been able to decide positively the true variation in power, but the difference is so slight, that it is not perceptible."

"What is the ordinary width of the tire of wheels of coaches?"—"I think about two inches; in a private carriage rather under two, and in stage-coaches over two inches."

"Of how many horse-power is your ordinary travelling engine?"—"Twelve nominal steam-engine horse-power; to work eight hours it takes the common stage-coach 32 horses; an engine propelling the same weight for eight hours should be considered a 32 horse-power, according to the rule laid down by engineers, but this is not true as to locomotive engines."

"Taking your latest improvement, to what number of draught horses would it be equivalent?"—"I think about 10 cwt. will do the work of a horse on the road; 35 cwt. will be about 3½ horses' work always."

"You mean that it will displace about three horses and a half at a time on the road?"—"Yes, in each stage it will displace 3½ or 4 horses, and about 30 horses in the eight hours."

"Is that in practice, or in idea?"—"Practice."

"Is the chief weight supported on springs?"—"The whole is on springs."

"What is the weight of an ordinary stage-coach?"—"About 24 cwt.; I think from 18 to 24."

"How many persons will that take?"—"I think about 18."

"What would be the weight of your engine carriage sufficiently powerful to draw a carriage containing 18 persons?"—"The weight of the propelling carriage would be about the weight of four horses; the weight of the carriage drawn would be precisely that of a carriage drawn by horses, and I find the weight of a horse to average about 10 cwt.; therefore, taking four horses at 10 cwt., the four horses would be two tons, which is somewhere about the weight of my carriage; to do the same work, some horses weigh as much as 16 cwt. some considerably less than 10 cwt."

"Have you examined the effect on the roads of the propelling wheels of your carriage?"—"As far as I am enabled to judge, I should say that they did no more injury than any other carriage of the same weight; I mean the carriage itself, weight for weight. I have taken the loss of iron from the tires of the wheels, and compared it with that of the loss from other carriages running the same number of miles, and I found the loss the same nearly."

"Do you find that the wheel never slides in the turn?"—"If it does, it is either imperfect or the fault of the engineer; if the steam is wire-drawn (using the technical term) it never does so; if the steam is laid on suddenly on the engines, it acts like a percussion, and affects the wheels as if struck with a hammer; the carriage, of course, would not be propelled in such case."

"Practically, as far as you have seen in the operations of these carriages, does the wheel slide in that way frequently?"—"It may sometimes at starting for an instant, but never on the road unless it is over-weighted; I mean, if it has an over-weight attached to it."

"Is there much smoke created by your carriages?"—"There is no smoke unless any smoky matter gets accidentally into the fire, the fuel being coke; of course there will be smoke if there are coals."

"Are you frequently obliged to let off steam?"—"Yes, but not openly; the steam is allowed to escape from the safety-valve into a chamber peculiarly constructed, which prevents any nuisance from it."

"There is no annoyance either from smoke or steam?"—"There is no annoyance either from smoke or steam when the engine is perfect."

"Have you found that horses are more liable to be frightened by passing your carriages, than passing other carriages?"—"As far as my own observation goes, I should say about the same; I have travelled with a carriage, I think, five years, more or less, every week; I have been very frequently in the public streets of London with the steam-carriage, and the roads round London, and also in the private and public roads in the country; I have certainly seen horses shy often, but never saw a horse make a dead stand."

"Is there a very peculiar noise attending the motion of your engine carriage?"—"The noise of wire-drawing, &c. is at the will of the engineer; if the carriage should make a noise, he has the means of stopping the noise; but there ought not to be any disagreeable noise."

"Must not the noise proceed from the imperfection of the works?"—"Yes, and that only."

"Do you attribute the startling of horses to the peculiar noise of the engine, or to its unusual appearance?"—"I think it must be from its unusual appearance. It appears from an observation on the carriages at Cheltenham, made in this Committee, to have been more troublesome than anywhere else; those carriages were made with curtains, to inclose persons who might ride in them, and the carriage altogether rather more *outrè* in its appearance, from the flapping of those curtains, or some circumstance of that kind, the horses have been startled, or accidents have occurred there."

"Are you aware that there is an imperfection in the carriage at Cheltenham, which is stated to occasion noise?"—"I have not seen much of these carriages; I was never at Cheltenham but twice or thrice, and then but for a short time."

"What have you found to be the effect of the wheels on a very rough road, full of ruts?"—"If you start the carriage from a rut it takes more power; but when the carriage is in motion, the momentum takes it over all the inequalities with the usual force."

"Do you find that when the propelling wheel gets into a rut the first power it exerts is in sliding?"—"Frequently; and sometimes it will be necessary to attach the two wheels, for one wheel will not be sufficient to get it out of that difficulty; the engineer, in such case, attaches a second wheel by the bolt, and I have never known a situation yet, in which a carriage with both wheels attached will not get out. I have seen it in a clay-pit, eight inches deep, propel itself through, having sunk through the upper surface of gravel in a yard."

"When you attach the second wheel, is the increased power owing to the more favourable situation of the cranks?"—"The power of the engine remains the same, but the application of it is doubled by friction."

"Suppose that both wheels were in the rut?"—"I have seen both wheels in a rut; in the case I have just spoken of they were both in the rut; in a different state of weather, the effect, hold, or bite on the wheels is very different: if the state of the road is between half-wet and half-dry, it is more apt to slide; and in some instances, with a heavy weight attached, we are obliged to go with both wheels locked, when the same weight would have been taken by one wheel only, in very wet or dry weather."

"Is it only in starting that that difficulty occurs?"—"Only in starting on a level or slight incline; but up hills we have sometimes been obliged to attach both wheels, the bite only from the one wheel being not sufficient to propel a load behind it."

"What is the operation of the propelling wheel when it meets with the obstruction of a large stone on the road?"—"If the difficulty is so great that the carriage cannot advance, it slips on the stone; but I have blocked up the wheels of the carriage with square pieces of wood four inches in diameter, and started it when so blocked up."

"In proportion to the size of such obstruction, there is liability in the crank to break?"—"Certainly; but the cause which occasions a crank to break is one which cannot be explained on common principles; it frequently happens, as in steam-boats; and very often in this carriage, when the power applied to it is not equal to its being broken, the accident occurs, and must be referred to a jar or percussion; the axles are unusually large in consequence."

"What is the throw of the crank?"—"Half the diameter of the stroke of the engine; eight inches and a half to nine inches."

"With a wheel of five feet diameter, what is the throw of your crank?"—"About nine inches."

"What is the length of the stroke of your cylinder?"—"I think, sixteen to eighteen inches; the crank is half that. I may state here, that I have had accidents of breaking the crank two or three times during my experiments; the last crank was broken in consequence of going through some rough stones laid unusually thick; I understand as much as eighteen inches deep."

"What do you anticipate will be the most frequent accident which will happen to your drawing-machines?"—"I should say the derangement of the pumps is most likely to occur, in consequence of which the carriage would merely stop."

"During the experiments you have been making, have you frequently had your tubes burst?"—"Very often."

"Do you conceive you have remedied the probability of such occurrence?"—"Yes: the first tubes we used were iron gas-tubes, which were not welded, but simply 'butted' together; the consequence was, that whenever any great pressure came upon them the seam opened; but from practice and experience, we found it necessary to wrap over, or over-lap the edges, and weld them from end to end; and now we are not subject to those accidents."

"What is the diameter of the tubes of your boiler?"—"We make them from half an inch to two inches; the best size, I think, is an inch diameter."

"To what pressure, per square inch, do you prove them?"—"To about 800 lbs.; I think they would bear 2000 lbs."

"What is the greatest pressure they would bear?"—"It is impossible to say; I have never been able to burst one when well made, when lapped and welded."

"What is the average pressure on the boiler, per square inch, in your ordinary rate of travelling?"—"About 70 lbs."

"And you have tried the tubes to 800?"—"Yes; we sometimes may work up to 100 lbs. and 120 lbs.; but that is a case of great emergency."

"What is the greatest probable pressure it will be exposed to?"—"Never more than 130 lbs.; the safety-valve blows at 70 lbs. to the inch; it is generally on the lift on a level hard road. I do not think that the pressure is more than 20 lbs. to an inch on the piston."

"Is it likely that persons would ordinarily work with the safety-valve on the lift?"—"Yes; or nearly so, sometimes."

"Is there not a waste of fuel when you work on the lift?"—"It will be in proportion to the escape of steam from the safety-valve. The pressure on the boiler is 70 lbs.; on the engine frequently it does not exceed 20 lbs. to an inch; and when I was asked the pressure I worked at, I supposed the question referred to the pressure on the piston collectively."

"What is the thickness of your tubes?"—"The thickness of the iron is about the eighth of an inch."

"What is the thickness of your working cylinder?"—"It is about three-quarters of an inch; it has also ribs round it."

"Of what metal is your working cylinder formed?"—"Cast-iron; we have worked gun-metal, but cast-iron appears to be best."

"Have you found that there is great facility in guiding those carriages?"—"I have always found the most perfect command in guiding them."

"Supposing you were going at your ordinary rate of eight miles an hour, could you stop immediately, or would the carriage run for any distance?"—"In case of emergency we might instantly throw the steam on the reverse side of the piston, and stop within a few yards. The stop of the carriage is singular; it would be supposed that the momentum would carry it far forward, but it is not so; the steam brings it up gradually and safely, though rather suddenly."

"Supposing you were going at the rate of eight miles an hour, can you say at what number of yards it would be possible to stop?"—"I would say within six or seven yards."

"How would you manage on a declivity?"—"On a declivity we are well stored with apparatus; we have three different modes of dragging the carriage."

"You have stated that you found no difficulty in guiding the drawing-carriage, nor any difficulty in guiding the carriage which is drawn?"—"Not the least; it is peculiarly connected, so that the fore wheels of the carriage drawn follow the tracks of the hind wheels of the steam-carriage drawing, although making a circle of fifteen feet in diameter, which is a singular property."

"In what circle do you think you could turn both carriages?"—"In a circle of ten feet, the inner diameter."

"Supposing you were going at the rate of eight miles an hour, in what inner circle do you suppose you could turn?"—"I should be very sorry to attempt to turn within a small circle; I think I might say, probably it might safely be done in one of one hundred feet diameter."

"In the further progress of the improvement of this description of carriage, do you suppose that greater weight will be drawn, by adding to the number of carriages, or by increasing the size of the one carriage drawn?"—"The carriage drawn with its load should never exceed three tons, and the carriage to draw it should never exceed the weight I have previously stated, about two tons, or 50 cwt.; it is possible to draw more than one carriage on good roads, but I do not think it would be a circumstance of common occurrence."

"What have the chief inconveniences been that you have met with on your journeys?"—"The principal inconveniences we have met with have been minor derangements of some parts of the machinery, such as the valves of the pump being deranged, or tanks leaking, or something of that kind. I never met with any serious accident, except perhaps the first accident in going up Highgate Hill, which was five years ago; the carriage was not then complete in reference to dragging. I went up the hill contrary to the expectations of every body present, and the workmen were so delighted at it that they neglected to lock the wheel. The carriage was started down the hill without any drag to it; it became difficultly manageable, and ran against a stone, and was upset. This is the only accident I have ever experienced myself; I believe Sir Charles Dance once upset the carriage in a first essay; those are the only accidents of the kind I am aware of."

"It has been stated that one of your engines has blown up at Cheltenham; is that the case?"—"I am not aware of that; I rather believe that the lifting of the safety-valve when the carriage stops, is considered to be a bursting, which I think must be so in this statement. I saw the carriages the day after the accident of the crank breaking, where it is stated to have burst, and certainly the carriage had not blown up then; nothing more than the safety-valve had lifted: I came to Cheltenham the day after the accident occurred."

"What was the nature of the accident which occurred?"—"The breaking of one of the cranks, occasioned by the extra difficulty the carriage was placed in. New stones were laid in a hollow of the road, I am told about eighteen inches deep; the carriage had gone through it twice with twenty passengers; the third time it fractured the axle, from the extra force necessary to get it through; the road was in an unusual state. I saw the passengers of a four-horse coach get down in the stones. I was told at the time, by people of great respectability, that all the two-horse coaches invariably put down their passengers; that the mail was stopped; that there were two waggons and two coaches in the stones stopped at the same time, and that they were obliged to exchange their horses to get through."

"Has any other accident occurred to that carriage, except that you have now stated."—"Nothing that I am aware of material."

"Have the wheels of your carriages frequently caught fire?"—"Never; I saw the three carriages the day after the accident; neither one had taken fire. I am sorry such an idea should for a moment exist; I think it has been occasioned by misconception or prejudiced mis-statements."

"Is the construction of your boiler and of your fire-place such, that it is impossible for the carriage to catch fire?"—"I believe it to be impossible."

"You have stated that you require to charge your engine once in seven miles?"—"Yes, to charge the tank with water, and to take fresh fuel."

"Do you anticipate, in the course of your experience, that you would be able to overcome that inconvenience of being obliged to charge so frequently?"—"We can now go double the distance; but we should have a weight of water, and a weight of fuel, a greater expense to carry than if we take in one charge at seven-mile stages."

Again, Report, page 24.

"Your steam-carriage, according to the last improvement, weighs 35 cwt. without the weight of persons to direct it?"—"Yes, and without the weight of the fuel."

"Do you not consider that the steam-carriages would be applicable not only to the moving carriages at a rapid rate, but also to moving certain weights at a slower pace?"—"I think it is possible, but it would be very expensive, because I find that when you get below a rate of four miles an hour, the expense in fuel is greater than the expense in horses; if the rate exceeds four miles an hour, then it is cheaper, and it becomes cheaper geometrically over horses as you get up."

"What is the greatest weight which you conceive your steam-carriages could draw after them on a level road, at the rate of four miles an hour, the carriage weighing two tons?"—"Every 10 cwt. in the engine would draw as much as four horses."

The frontispiece to this work is the last constructed of Mr. Gurney's carriages. A, the position of the boiler above described, (see Plate X.) B, the steam-pipe, which passes under the body from the boiler, till it comes to the fixed point N, and from thence down to the valve boxes, C, of the cylinders, D D. N N is a fixed point, on which the body rises and falls as on a hinge, when the spring above the hind axle has play. If the steam-pipes were not brought close to this point, they could not be kept tight; otherwise the play of the springs would disturb them, and occasion leakage. E, the wheel of the parallel motion. The wheel E runs horizontally betwixt the parallel bars, G.

Through this wheel there is a spindle or axle, upon the ends of which a forked or double connecting rod, F, is attached; so that in the revolution of the crank K, the parallel bars are in the inside of the double connecting rods F. The two engines, which are shown in the "plan," exhibit this more distinctly as they are at different parts of the stroke, for the purpose of getting over the centres. At H the water-pump is placed, (each engine having a separate one), and each pump is worked by a connection with the piston-rod of its corresponding engine. The valve motion is obtained from eccentrics on the crank-shafts outside of the cranks. The valve-rods are distinguishable by being represented with strong black lines. At the extreme ends of the crank-shaft, (i. e. the hind-axle of the drag), and betwixt the spring and the wheel on each side, are seen P P, (black in the Plan and white in the Section). This is a contrivance for conveying the power from the crank-shaft to the circumference of the hind-wheel, in order that a light wheel may be used. It will be seen that the driving-arm in the " Section," being pressed up by the engine against the bolt which is shown above it, must force the wheel in that direction, and thus propel the carriage by the wheel's friction on the road. One or both of the hind-wheels are thus used, as occasion may require. If the bolt be withdrawn, of coarse the driving-arm P will revolve without propelling the wheel; and thus one or both wheels may be used to propel the carriage. It is found in practice, that one wheel is sufficient to propel the carriage *even up hill;* and the provision of the driving-arms is more a matter of expediency than necessity. J, upon the " front view," " section," and " plan," will explain how the carriage is turned. M is the wheel fastened on the top of J, which the conductor turns in the *same direction* he wishes the carriage to turn. The pinion on the lower end of J works in a rack, which is made fast to the front axletree. And it will be seen, that if the conductor, who sits on the box, turns the wheel (on which his hand rests) to the *right,* the pinion will haul the rack round to the *right;* and thus the front wheels will be as effectually turned to the *right* as if they were turned by horses: indeed with more certainty. On the foot-board is placed a lever L, which, when pulled up by the conductor, reverses the motion of the engines, and so stops the carriage or propels it backward if necessary. The shape of the body of this steamer is what coachmakers call a " brisca." It is entirely used as a drag for other carriages: a private carriage will be seen behind it. No passengers are allowed to be in this drag: the coach-box being occupied by the conductor, and the interior by the boiler at A, and by the engineer with fuel and water at R. Upon the highest point of the steam-pipe B B, there will be seen a handle, which can be turned by either the conductor or the engineer for the greater or less supply of steam. Mr. Gurney has placed the chimney in the back of the body, and it is so constructed that it cannot be seen by horses on the road. The water for the boiler is poured in to the tanks through a funnel which resembles a " dickey " on the hind boot.

To start the carriage: raise the steam in the boiler, A, by a good fire. When it is of sufficient force, the conductor, who sits on the coach-box, opens the steam-cock by the handle at his side, and the steam finds its way along B B, to the cylinders D D.

Let us turn again to Mr. Gurney's evidence, (Report, p. 27.)

" Having ascertained that it will evaporate nine gallons of water in an hour, you come pretty nearly to the expenditure of one-horse power?"—" It does not follow in all cases, that one-horse power will be practically produced from nine gallons; and on the other hand I may state, that I have seen a horse power produce it from five and six gallons."

" At what pressure?"—" It does not signify much at what pressure."

" You say that the evaporation of nine gallons of water is equal to one-horse power; does it not make a difference according to the pressure?"—" This is a point unsettled at present by engineers; some advocate high, others low pressure."

" You have stated, that if you wished to increase the power of your engine, you would increase the weight of it, and decrease the size of the wheels?"—" It might be done either way; the union of the two is not necessary as far as regards the intensity of power; the quantity of power must be produced by an increase of weight, or by some increased or rapid formation of steam."

" What is the weight of a loaded waggon, with horses?"—" At this moment I am not prepared to give an accurate answer, but I should think six tons."

" Does that include the weight of the horses?"—" No."

" What should you judge to be the weight of the horse usually attached?" —" From fourteen to sixteen cwt. each horse."

" Would not you, by increasing the size of the cylinder, increase your power?"—" Yes, in direct proportion with the increase of the area."

" What objection do you see to increasing the size of your cylinder, and applying it to a large waggon, so as to use steam-carriages for the mere carriage of goods?"—" I think the difficulty and objection lies in the management practically; it would be difficult in our present stage of knowledge and experience to manage a large cylinder very rapidly on the road; but I see no other obstacle to great speed; there is no theoretical difficulty. I would wish to state, in connection with my former evidence with respect to fuel for working slowly heavy carriages, that my opinion was founded on some peculiar laws of momentum lately observed: it is well known that one engine, when worked at a given rate, works expansively; that an engine working at a quicker rate, if a piston only travels half a mile an hour, or fifty feet a minute, it will require more fuel for it to do a given work, than if working at two hundred feet a minute."

"Is not the momentum gained by greater velocity an accumulation of power?"—"I think the advantage gained by certain rapidity of action arises from the inequalities of the road being overbalanced by the momentum of the carriage; when the carriage travels slowly, every inequality, every stone or slight obstacle partly destroys the momentum, but at a certain speed it overcomes them; there is no actual gain of power by momentum; it is only an accumulation very much like that in a common fly-wheel; and in a carriage on a common road it acts on inequalities as a fly-wheel does, in overcoming unequal obstacles in machinery."

"You use coke only?"—"We occasionally may use charcoal, but very seldom."

"What is the proportion in price and what in value between coal and coke?"—"I think one bushel of coals is equal in raising steam to two bushels of coke."

"What is the difference of price on the average?"—"The difference of price is, I think, about two-thirds."

"Then there would be a loss as compared together in using coke?"—"Coals would be much cheaper than coke, but that loss in the expense of fuel we are disposed to suffer rather than produce a nuisance on the road by smoke."

"Do you conceive that there can be no mode of escaping that by any smoke-consuming apparatus?"—"I know of no mode that is likely to succeed, nor do I conceive that it is possible to make such a combustion of coals that is likely to consume all the sublimated or volatilized matter; the consuming of smoke or the combustion of smoke is prevented principally by the particles being mechanically mixed with or surrounded by carbonic acid gas. I believe it not to be chemically combined."

"Would not the motion of the carriage and the current of air that is produced by going quickly through the air give great facility in the application of a smoke-consuming apparatus?"—"If the consumption of smoke depended on the presence of oxygen gas or atmospheric air which contains it, I think it would; but on my previous reasoning, I do not think the consumption of smoke would be effected by any quantity of atmospheric air. I have made several very extensive experiments on this subject, and the only experiment that I have succeeded in was by passing it through sand mixed with quick lime, by which the carbonic acid was absorbed, and the smoke, as it passed through the mixture, rendered combustible; the carbonic acid was removed to a considerable extent, and left the carbonic oxyde and hydrogen gas in such a free state as to be combustible."

"Of what materials are your propelling-wheels?"—"The same as a common stage-coach wheel."

"Are the wheels of the carriage drawn nearly of equal diameter with the wheels of your drawing carriage?"—"Rather less; the diameter of the wheels of the drawing carriage is about five feet, and the ordinary diameter of a stage-coach that is drawn is about four feet six."

"From the experiments you have made, supposing the drawing carriage and the carriage drawn were of equal weights, what do you think would be the different proportion of weight on the wheels?"—"None."

"Do you speak that with any certainty?"—"Yes, I do. I have taken the loss of iron upon coaches after knowing the number of miles they had travelled over, and the loss of iron on the steam-carriage, and the number of miles it had travelled over, and find that the loss in both cases bore the same proportion."

"Is coke alone used on the rail-ways in the locomotive-engines?"—"On the Manchester and Liverpool rail-road, I believe there is a clause in their Act to prevent any nuisance being made by smoke, and coke is therefore used; but in the ordinary rail-roads in Wales and other places coal is used."

"In what part of your engine is your safety-valve situated?"—"It is situated at the option of the engineer; frequently in the steam-pipe leading from the boiler to the carriage; most generally so that the steam as it passes through that pipe may lift the safety-valve, or it may go to the engine, as the state of pressure shall determine."

"Do you make use of one or two safety-valves?"—"Only one. I occasionally use two, but we now use only one."

"If your carriages were brought into general use, would you suggest that two safety-valves should be required, one out of the reach of the engineer to prevent accidents occurring from racing, or other causes which could induce the guide to increase the pressure of steam?"—"I should recommend one being locked, and an inspector being appointed to examine it every journey. Perhaps I may be allowed to make an observation or two with respect to the bursting of boilers, which subject, I believe, is now under consideration. From experiments which I have made in connection with this subject, I am led to believe that the bursting of boilers is not always occasioned by pressure of steam. I have discovered that at a certain degree of temperature, and under certain circumstances, when water is decomposed, the hydrogen is often formed into a new state of combination with oxygen and nitrogen gas, which compound is exceedingly explosive; so much so, that I believe scarcely any provision that we can make in the shape of a safety-valve would protect the vessel. This was a subject which I was led to some time ago, from some observations which I had made on the combinations of oxygen and hydrogen only. I had some conversation with Gay Lussac on this subject, and he was of the same opinion with myself, particularly that there were different chemical compounds of hydrogen and oxygen gasses which at present were not acknowledged. The only one acknowledged in this country is that forming water. A compound of two proportions in volume of oxygen and two of hydrogen has been chemically combined in Paris, although I believe we never have succeeded publicly in this country. This compound was highly explosive when brought in contact with certain substances."

"It would be by expansion?"—"By chemical contact; if brought into contact with certain substances, it would be so affected as to produce explosion. I have reason to believe from some original experiments, that there is a compound of these elements produced under certain circumstances in steam-boilers. The want of water in a boiler is favourable, in which case the temperature is raised and the compound formed; the bursting of boilers I believe frequently takes place from this compound coming in contact with substances that will decompose it; and perhaps I might mention this fact, as it is a very interesting one, namely, that boilers often burst when the valves are known to blow at a pressure very considerably lower than the boiler has been proved to."

"Does not that take place also when the water is in the boiler?"—"If the water is low in the boiler it will take place; if it is high, never."

"Has it not frequently happened that boilers that were calculated for a higher pressure have even burst at a lower pressure than they were intended for, when water is in them?"—"When water is high in them, never; but when it is so low in them as to form this chemical compound, it does. I would state a fact, which was mentioned to me by my friend Sir Anthony Carlisle, which throws considerable light upon the subject, and first led me to my suspicions and experiments respecting it. The case was, that a boiler at Mr. Meux's brewery, with an open top—a common caldron—burst with a violent explosion. I believe one man was killed, and two very severely scalded. There was no cover at all on the vessel. This phenomenon, upon inquiry, appeared to be occasioned by gelatinous matter, forming a crust, a film, or blister, and prevented the contact of water with the bottom of the boiler; the bottom of the boiler, consequently, got hot; the compound I alluded to was formed, or the rupture of this film, and the sudden contact of water against the hot surface below, produced such an immense and sudden volume of steam that it burst the boiler. I would explain it by saying it was analogous to the bursting of a gun, in which case an ounce or two of shot is placed only against the charge; whenever there is a sudden formation of elastic matter, and there be ever so small a weight opposed, the shock will be very great, and a gun will frequently burst, though there is not an ounce of shot in it, and which charge may be considered in the light of a safety-valve in this case."

"What precautions have you taken in your boilers, that there may be no probability of their being without water?"—"This compound never forms without a certain raised temperature. Before this temperature, necessary for decomposition, takes place, it melts a fuseable compound alloy of metal, placed so as to allow of its escape; the matter formed escapes, and all danger is prevented."

"Have you any precaution to prevent the water escaping out of your narrow tubes, by bubbles of steam?"—"Yes; that I would explain by reference to the drawing, which will show that the bubble of water, as it escapes from a tube in connection with a part of the boiler, is supplied simultaneously from the lower part of the tube, and a stream of water is thus made constantly to pass through."

"Would not that stream of water act as a safety-valve?"—"When there is water it is sufficient, but when water gets down in any boiler, there is no safety-valve that will protect it, and hence arise the inexplicable accidents that have occurred frequently in steam-boats; the size of the boiler is the only protection without the safety alloy."

"Have you any gauge, or means of ascertaining when there is a deficiency of water in the boiler?"—"Yes; the melting of the safety-plug, I would state, only takes place in cases of great negligence, or in cases of extremity. The gauge by which we ascertain the quantity of water in the boiler is the common glass gauge, well known to those acquainted with the subject."

"Have you any gauge to examine the intensity of the steam?"—"Yes, we have a piston which is forced out in proportion to the pressure; in addition to the glass gauges there are also stop-cocks, so as to ascertain, by turning them, the actual height of water. I beg to state, that the safety-plug has never, but four or five times, given way in all my experiments, and that has been in cases where we have been accidentally out of water in our tanks; no personal mischief can arise from such an accident. I am satisfied, without this plug an explosion would have taken place in some of the tubes. In large boilers, under those circumstances, inevitable destruction would have attended it."

"Are you aware of the size of the cylinders and stroke of the engines on the Manchester and Liverpool rail-road?"—"I believe them to be ten inches diameter, and about fourteen inches stroke. In some of the later engines I believe they have been made of fourteen inches diameter, the stroke being the same; but I rather think that that size has been given up, and that they have returned again to the ten inches diameter."

"What is the greatest weight, in proportion to its own weight, which any carriage draws on a rail-road?"—"A carriage was originally supposed to draw only three times its own weight on a rail-road; but in some experiments which I made in Wales with Mr. Crawshay, of Cyfaithfa Castle[1], we

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[1] I have endeavoured to obtain the particulars of this work, but have not been able to procure them, though this amount of work is not uncommon within the last two or three months. In the Cambrian newspaper will be found an account of the first experiments at Cyfaithfa, in March, 1830; it is as follows:

"*To the Editor of the Cambrian.*

"Sir,—As I have reason to expect that a report will be sent you of the arrival of Mr. Gurney's steam-carriage at my father's works at Hirwain, and of the experiments made of its powers on a rail-road there, I think it better to inform the public (now so much interested in the subject of steam conveyance) through your medium, of the actual facts that have been witnessed in the experiments made, and under what circumstances.

"Mr. Gurney, at my most earnest request, while I was in London three weeks since, consented to bring one of his steam-carriages, which had been built and adapted for drawing coaches on turnpike-roads, to try her powers on our new rail-road on Hirwain Common. I had considerable difficulty in persuading Mr. Gurney to accede to my wishes, principally on the score that he had pledged his exertion and attention to the exclusive point of turnpike-road steam-conveyance, and had declined similar invitations to the one I so much pressed; and upon the ground that his carriage being built solely for the turnpike-road, would not be as well adapted for rail-roads as though made and calculated intentionally for them.

" The engine was brought from London to Cyfaithfa by a pair of horses, on the wheels used in its usual occupation of steam travelling in the neighbourhood of London, and was here fitted with cast-iron wheels, and otherwise adapted to the rail-road, of which a small piece, similar to that at Hirwain, was laid down for the purpose.

" The engine, with water and fuel, weighed thirty cwt., two-third parts of which weight are calculated to press upon the hind wheels, which are alone attached to the engine. The only experiment capable of being made here was that of starting a dead weight on a single carriage, on a very short piece of road.

" Twenty-three tons of iron, cast in long square pigs purposely, were placed on one carriage weighing twenty-five cwt., which was all that could, without danger of falling, be placed upon it, and the engine attached. The steam being gently thrown on, the engine moved forward with the load to the extent of the range admitted. This experiment was repeated until the load was drawn too far, and the weight broke the rails next adjoining those which were alone strong enough to support it.

" The cast-iron wheels, both under the engine and the load, were in this instance new, and the surface of the rail (also cast-iron) nearly so, though as smooth as it could be rendered by cleaning off the sand.

" Mr. Gurney then proposed to run the engine alone, upon the same rail-road wheels, up the common road to my residence, which he did; and the ascent in this road, which is a perfect inclined plane, is 3¼ inches in a yard, and at the termination (in the entrance of the stable-yard) are sixteen feet in length on a rise of two feet in the sixteen, covered with fresh-broken limestone. The engine propelled the carriage with perfect facility up this elevation, and repeatedly turned and cut the figure of eight, in a pitched yard of seventy-six feet long, by forty-eight feet wide, never upon any occasion using more than two-thirds of this room for such turning.

" On the following day, the engine was sent to Hirwain, and placed upon the rail-road, which is a dead level of three miles in length, and in the presence of many gentlemen and engineers was pronounced to be ready for starting as soon as the steam was up.

	Tons.	Cwt.	Qrs.
" A load consisting of pig-iron weighing exactly	10	0	0
Upon five carriages, weighing 16½ cwt. each	4	2	2
One ditto, fitted with seats, &c.	0	19	0
Upwards of 100 persons, say 100 only, at 120 lbs. each....	5	7	0
Making together.......... Tons	20	8	2

was attached to the engine.

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found, in an experiment, that a carriage draws thirty times its own weight. He has the minutes which we made upon the occasion; but I believe, in practice, they scarcely exceed five times, or from five to ten."

"You have stated that in your carriages you do not anticipate drawing more than the weight of the engine?"—" Practically, on the common road, weight for weight. I explained in my former evidence, that it was possible to do more under favourable circumstances; but circumstances vary so much on the common road, that we ought not to calculate on doing more than weight for weight."

" I requested Mr. Gurney to permit me to lay and light the fire, as he had informed me his boiler was capable of getting up steam in ten minutes. I laid the fire myself, and from the moment I applied the light, four minutes and fifty seconds only had elapsed ere the steam was up: many gentlemen and engineers timed and witnessed this fact.

" The engine started with the load attached, weighing, as I before enumerated, 20 tons, 8 cwt. 2 qrs., (and at this time there was an addition of many other persons, to the extent of forty-seven), and drew the whole, without stopping, the full distance of the road, say three miles, in thirty-nine minutes, blowing away spare steam the whole way. After turning the engine, (which had not then a reversing motion), it returned with the same load to the place whence it started, in thirty-two minutes.

" The subsequent days have been devoted to various private experiments and trials, all of which have most satisfactorily proved the extreme capability of the power of raising steam by Mr. Gurney's boiler; and yesterday I again invited several gentlemen to witness a further experiment of the engine upon wheels with wrought-iron rings.

"The result was, that the engine drew a load of 21½ tons upon the same three miles in nineteen minutes, and returned in eighteen minutes; and after this, the engine itself was loaded with 10 cwt. of pig-iron, making its own weight 40 cwt., and attached to a load of 33 tons, 18 cwt., which she drew at the rate of about 2¼ miles to 2½ per hour; and in this, as in every experiment performed, steam was, during the whole working time, blowing waste. The wheels were quite new, never having before been used, and consequently giving an advantage in adhesion to the engine, which probably will not be found when the rings of the wheels have assumed a smoother surface.

" In the trials upon cast-iron wheels, the wheels had been more worn, and were comparatively smooth.

" Having faithfully detailed the principal experiments performed up to yesterday, I shall only call the attention of your readers to the following points:—In all the cases named, Mr. Gurney's engine has drawn from 15 to 16½ times her own weight, upon a level road, and has produced more than sufficient steam for the purpose: that the surfaces of the wheels have been in the first experiments of cast-iron, and in the latter of wrought-iron; and that in all cases the rails of the road were of cast-iron, and have been laid down and in constant work only within the last twelve months, and are consequently at this time in a more favourable state for the performance of a locomotive engine than they probably will be when more worn and polished.

I am, Sir, your obedient servant,

" Cyfaithfa Iron Works, WILLIAM CRAWSHAY, Jun."
18th March, 1830

"The diameter of your steam-wheel is rather greater than the diameter of a carriage-wheel?"—"Yes; the size of the wheel I proportion to the engine, so that the piston may work under the most favourable circumstances."

"It is by experiment simply that you have arrived at your present size of cylinder?"—"Yes."

"You stated in your former evidence, that you anticipated that passengers would be carried at one-half the rate by your steam-carriages that they are by the common carriages; what difference in the ordinary expenses of carriage would it make if you had a paved road for this purpose?"—"I think that it would reduce the expense to one-half again."

"If there were properly paved roads, you conceive that passengers might be carried at one-fourth the present expense?"—"Not exactly; because the total expense includes the government duty, tolls, &c. as the same; but as far as the steam-power is concerned they would. These subjects have been inquired into by a mathematical friend of mine, and he has published the result of his inquiries."

"You have stated that in certain states of the road you find increased difficulty than in other states?"—"I have; and the difficulty arises from a mechanical application of the steam simply; namely, in consequence of the road being in a greasy state, and the wheels therefore more easily slipping, and under the circumstance do not furnish so good a fulcrum for propelling."

"Have you ever watched the operation of your carriages in snow?"—"I have; I have used them both on snow and on ice. On ice, a very little roughing of the wheels is necessary, in the same manner as you rough horses, and little power is sufficient to propel the carriage, because under those circumstances the power to draw the weight is very considerably reduced, and therefore the full power of the engine is not necessary to be exerted: in deep snow, there certainly is great difficulty; but I have no doubt that as the subject goes on improving, all those practical difficulties will be overcome."

"The difficulty would be greater in your carriage than in other carriages, would it not?"—"I think not; I think the carriage might be so constructed as to remove the difficulty."

"Will you state the effect of ice below, and snow above, upon the action of your carriages?"—"I have had occasion, in two or three instances, to use the carriage under those circumstances, with a view of judging of the practical result of it; and I have not found any difficulty in its progress. The snow is pressed strongly under the wheel, becomes almost immoveable, and furnishes a good fulcrum for the wheel; a little preparation only is necessary, and a very little is sufficient to overcome any moderate obstacle of that kind."

"To what width could you extend the tire, without any inconvenience to the working of your carriage?"—"At present I cannot say to what limit it may be carried, but six inches would be no inconvenience."

"Then your carriage would go with six inches tire?"—"I think so; and under certain circumstances easier, where the crust of the road is hard."

"Would not that depend very much upon the road?"—"It would; I would state general principles: I would submit to the consideration of the

Committee, better to explain my meaning, that it frequently happens that a frost forms a crust sufficiently hard to support the weight of a carriage a ton weight, but that it breaks under one or two tons: the power required to draw two carriages respectively so circumstanced is so great, that I can give you no data for estimates off-hand; but it is evident, that the power of drawing a one-ton carriage would be little compared with the proportion of power required for drawing two. My answer to the question is, generally, as I find the public roads at this time."

"To what velocity could you increase your present rate of travelling with your engine?"—"I have stated that the velocity is limited by practical experience only; theoretically it is limited only by quantity of steam: twelve miles, I think, we might keep up steadily, and run with great safety. The extreme rate that we have run is between 20 and 30 miles an hour. I stated in my former evidence, that the carriage, when upset by Sir Charles Dance, was at that time going at 18 miles an hour, but no injury happened either to the machinery or the persons upon it; still I am of opinion, that that speed might be maintained with perfect safety by a little experience in practical management."

"What are the practical objections to going at that rate?"—"I think the principal objections are want of real knowledge and experience; I have been so many times disappointed in what theoretically I had imagined true, that I am afraid to give a decided opinion on subjects not practically proved."

Mr. Alexander Gordon examined. (Report, p. 77.)

"Complaints have been made that a great inconvenience arises to passengers along the road from the use of these carriages, from the horses being frightened, in consequence of the peculiar noise, the smoke, and the letting off the steam; have you seen any inconvenience of that kind?"—"I have seen one case where a gig ran off for about two hundred yards, and was then stopped without any accident. I have also seen the same thing happen with a stage-coach; it is a common thing with a young shy horse. I have seen Mr. Gurney's coach at work in the Barrack-yard, in the Regent's Park, and have not seen the horses frightened there."

"Should you say you have seen a much greater number of cases of horses being frightened and running away attending the use of steam-carriages than of common coaches?"—"My experience in steam-carriages is limited, and so must be that of every one when compared with the experience had with ordinary coaches: I have seen Mr. Gurney's engines going through the streets of London, and I have not seen horses frightened in any case; they may shy and prick their ears, but they have not started."

Mr. Joseph Gibbs examined. (Report, p. 78.)

"Are you an engineer?"—"I am."

"Were you brought up to that business?"—"I was."

"Are you the patentee or proprietor of a steam-carriage?"—"I am patentee of a new method of more economically and safely generating steam, which I am applying to steam-carriages."

"Has it been practically carried into effect in steam-carriages?"—"No; I am building steam-carriages, one of which is complete. I have been to Cheltenham to see the effect of a carriage there, and travelled nearly 100 miles between Cheltenham and Gloucester, with Mr. Gurney's carriage with that view."

"Did you find that any inconvenience arose to the persons travelling upon the roads from Mr. Gurney's carriage?"—"I did not observe any particular inconvenience: certainly the horses shyed a little; that may be accounted for from too great a quantity of fuel being consumed, which caused too great a smoke and vapour, but that will be reduced as improvements take place."

"Have you paid attention to the effect on the roads of Mr. Gurney's steam-carriage?"—"I have."

"Will you give the result of your observations?"—"I conceive that steam-carriages do no injury to the roads further than the carriages at present in use; no horses being applied, there is so much diminution of injury to the road from the horses not being used; the wheels I do not conceive do any more injury than those of a stage-coach, supposing them of both the same weight."

"Then deducting the weight of the horses, do you conceive that the injury is the same weight for weight?"—"Precisely."

"What opportunity had you of examining the state of the roads after the carriage had passed over?"—"I frequently went in a carriage attached to the steam-carriage; passing behind it, my object was to know the right width a wheel ought to be made to obtain sufficient traction, and I never saw any mud displaced which was upon the wheel during its revolution. I particularly remarked the indentations in the tire which will be made in consequence of the wheel coming in contact with the sharp flints upon the road. Now if the wheel had slipped, the tire would have been graved or cut into small furrows; but that was not the case; I had the wheels cleaned in order to observe the effect."

"Did you go up any hills?"—"The hill going into Gloucester."

"At what elevation?"—"That I cannot say exactly; it is a considerable hill."

"Do you conceive great improvements will take place in Mr. Gurney's carriage?"—"I conceive great improvements will take place in all steam-carriages; that they are in their infancy; that there are not yet sufficient practical data to form a perfect judgment by, as to the ultimate shape of the vehicle, arrangement of parts, and weight of machinery."

Mr. James Stone called in and examined. (Report, page 87).

"What are you?"—"An engineer."

"Have you had the superintendence of Sir Charles Dance's steam-carriage [1]?"—"Yes, I have."

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[1] Mr. Gurney's invention.

"On what road does it run, and how long has it ran on that road?"—"It was running regularly from the 21st of February to the 22d of June inclusive."

"During that period, has any accident occurred?"—"Yes, by the breaking of the axletree."

"Mention the nature of the accident."—"We supposed it broke in consequence of an unusual quantity of stones laid down upon that part of the road that was always the most difficult to pass over; but no accident as to the bursting of the boiler, or any other thing took place, that occasioned any unpleasantness, or any thing like a serious accident as to injuring any persons. We had several little stoppages from defective tubes, of which the boiler is constructed; but nothing accrued from that, except merely stopping the progress of the carriage."

"Was the carriage able to work with the axletree broken across?"—"It broke about a mile and a half from Cheltenham, and it came back all the way to Gloucester, notwithstanding the axletree being broken. One of the engines was able to work during that time; and, of course, having only one engine, when it came to a hill, the men were obliged to assist it over the centre, as there was no momentum."

"Can you state accurately the weight of the carriage?"—"I cannot."

"As far as you have observed, is the injury done to the roads by the passing of the carriage greater or less than that by a carriage drawn by horses?"—"I think, taking the horses into the account, the injury must be much less: the tire of the wheels is three and a half inches wide, whereas many of the stage-coaches are as heavy as the steam-carriage, and with narrower wheels; and I think it only fair to take the weight of the horses into the account, which I have found to be from eight to ten hundred weight each horse, consequently four horses would weigh from a ton and a half to two tons."

"You are answering now from theory; you were directed to answer from observation."—"From observation, I do not think that the steam-carriages injure the road so much, from the wheels being wider."

"How frequently do you clean the tubes of the boiler?"—"It would be necessary to clean them once a month; I should recommend that, but if they were actually cleaned once in three months, they would not give way; it depends upon the quality of the water made use of."

"Is there great facility in cleaning them?"—"Very great; it is merely removing opposite the end of the orifice of the tube the screw-bolt; it is only to withdraw the screw-bolt and introduce the cleaning-rod. We are in the habit of blowing out the tubes every two or three days, to cleanse them."

"What is the greatest number of passengers you have taken on that carriage?"—"Thirty-six."

"Thirty-six passengers and their luggage?"—"Yes; but being a short stage, there is never much laggage."

"What do you suppose is the greatest weight you could draw by that carriage, at the rate of ten miles an hour?"—"From forty to fifty hundred weight; it is found to be drawn much easier by dividing the weight into two carriages, than taking it in one only."

"Do you work, on an average, at half your utmost power of working with safety to the engine?"—"I should think we did."

" Full half?"—" Yes."

" Do you think more than that?"—" It depends so much upon the state of the fire."

" The question was, Do you work, on an average, at half your full power?" —" Yes, I should think we did. The greatest weight we ever drew on the common road, at a rate of from five to six miles an hour, was eleven tons."

" Is that merely by guess, or did you actually weigh?"—" By weight; we made the experiment on the Bristol road."

" What should you suppose to be the weight of the drawing-carriage?"— " The weight of that was upwards of two tons."

" Then it drew five times its own weight?"—" Yes, it did: the eleven tons I have stated included the weight of the drawing-carriage; and I did not consider that the maximum power at all."

" Did you ever try it at a less velocity?"—" No; because, in applying the greatest power, we confine both the wheels to the engine."

" Did you draw the nine tons with only the power of one wheel?"— " Yes."

" Are you able, from the two circumstances you have mentioned, to say, that at three miles an hour you could draw considerably more weight?"— " Yes, I have no doubt of it whatever."

" On what breadth of tire was that weight drawn?"—" I think the tire was five inches of the propelling-carriage."

" For what distance did you continue to draw that nine tons?"—" A mile and a quarter."

" Did the road vary in the inclination?"—" Yes, a little; the greatest elevation could not be more than one in twenty-five."

" Did you ascend an inclination of one in twenty-five with that weight?"— " Yes, we did."

" For what distance?"—" From twenty to thirty yards."

" And, on the average of the mile and a half, was it an ascending or a descending road?"—" It was both; there were little undulations in the road."

" Can you measure accurately the power you are employing at any particular time; have you any gauge?"—" No, we have never applied one; I have conceived one, and am going to apply it."

" A barometer tube?"—" Yes, that is the one. I think it right to state, that the wheels were taken off that measured five feet diameter, and others were substituted, measuring only three feet diameter."

" Do you wish to have it inferred from that, that you employed in both cases the same amount of power?"—" There must have been a little more power with wheels of three feet diameter."

" Do you think you exerted your utmost power when you were drawing nine tons?"—" No, and for the reasons stated, that there was only one wheel affixed to the engine."

" May you not exert your utmost power upon one wheel, taking into consideration that the strain is greater?"—" No, the wheel would slip round."

" Was the surface of the road on which you tried that heavy weight broken up, or in any way rough, to give a greater amount of friction?"—" No, it was a good hard road."

"What proportionate charge do you make for conveying passengers between Cheltenham and Gloucester?"—"One shilling."

"What do the coaches charge?"—"Half-a-crown the four horses, and two-horse coaches two shillings."

"Travelling at the same speed, do you think you could charge in the same proportion?"—"Yes."

"There would be a saving to the public of more than one-half?"—"Yes."

"Have you taken many passengers?"—"Yes, a great number; from February to June, between three and four thousand passengers. I have a book containing an account of the number of minutes that each journey took."

"The Committee have received a letter from the Surveyor of the Gloucester and Cheltenham road, stating that there is a very great noise proceeding from this carriage?"—"I have not heard that observation generally; there is a little noise, but not much."

"With red-hot burning coals falling on the road continually, or whenever the fire was moved?"—"That has taken place when the ash-pit has been burnt out, but that is not necessary; the carriage I have recently fitted up will not be subject to that."

"You are of course aware that the letting coals drop is desirable to be obviated?"—"Yes, and that I have guarded against."

"He also states, few animals will pass it without being frightened; and often the traveller was obliged to take his horses into the fields adjoining the road; and very many who did not use that precaution had been placed in the most perilous situations; and that a gentleman's carriage, in the neighbourhood, was overturned from the horses taking fright at it?"—"Yes, I have understood that; but that carriage has been overturned once or twice, owing to the carelessness of the driver. I have seen the gentleman, and he did not think any thing of the accident; the coach turned round, and the coachman jumped off; but I never saw any thing bordering upon an accident during the time I was with it."

"He states, that persons have completely deserted that road?"—"I have never known but one individual that has been against it at Gloucester; but I have seen horses take fright at a stage-coach, and not at our carriage. In one instance, going out of Gloucester, we were just behind the stage-coach, and a horse in a chaise coming past took fright at the stage-coach, and when he came up to us, he took no notice of us; and therefore I am fully persuaded that horses do not take more fright at us than at a loaded stage-coach, from the observations I have made upon a number of experiments."

"Were there fourteen inches of stone laid on the road at the time the accident happened of the breaking of the axletree?"—"Yes, there was. When the stones were levelled, they measured seven inches; but at that time they were merely laid across the road, so that the carriage could not pass them without going through them."

"Do you know that the passengers on the common stage-coach got out and helped the coach along?"—"No, I do not know it; I only heard it; I do not know it."

In May, 1831, Mr. Ward made several trips in and about

Glasgow with one of Mr. Gurney's carriages, similar in its construction to those on the Gloucester and Cheltenham road. These experimental trips were, however, not of a nature the owners could have wished. This carriage had been hastily put together, and shipped off to Leith. On the voyage the engines received some injury, which not being perfectly repaired, occasioned the disappointment of delay in the introduction of steam-carriages in that quarter.

On the 22d of May, a trip was made with nine passengers on the steam-carriage, from Glasgow to Paisley, and back by Renfrew to Glasgow, at the speed of between nine and ten miles an hour. We hope that part of the kingdom, which may be styled the nursery of steam navigation, and where the power of machinery and all its detail are known and appreciated, will be amongst the first to cradle infant locomotion into greatness.

Mr. Stone's experiment (above-mentioned in his evidence) on the Bristol road, near Gloucester, as to the power of one of these steam-carriages, was made by taking off the hind wheels, so as to reduce the speed and gain power. A pair of three-feet wheels were used on the hind axle, and the engine drew with ease a large waggon loaded with cast-iron. After going about a mile and a quarter, a cart, also loaded with cast-iron, was attached to the waggon. The engine started with these loaded carriages, and returned to Gloucester. The additional weight made so little apparent difference to the engine, that in the way back several persons among the spectators got up and rode; the number altogether amounted to twenty-six. The waggon and cart were weighed at the toll-gate, and found to amount to seven tons, eight hundred weight; this, with the twenty-six, made nearly ten tons. This was done with only one wheel attached to the engine. Going into Gloucester there is a rise of about one in twenty, or twenty-five. The wheel did not slip, and there was no occasion to bolt the other wheel. The road on which the experiment was made is comparatively flat and hard.

It was a matter of great regret, that any interested individuals should have it in their power to delay a national benefit by their opposition. A Pamphlet has recently been published by Mr. Gurney, detailing some of the difficulties he had to encounter; and as the proceedings which interested persons took against the invention are described in a postscript to that Pamphlet, it may be well to quote therefrom, in the words of Sir Charles Dance to Mr. Gurney.

"*Hertsbourne Manor Place*,
"*Feb.* 3, 1832.

"Dear Sir,

"I have read the copy of your pamphlet, which I return herewith. I think you are right to publish it, for although the Report of the Committee of the House of Commons, last October, is very satisfactory, it cannot be generally known to the public. If you think the following *facts* will be of any use, you are welcome to state them on my authority.

"My steam-carriages ran between Gloucester and Cheltenham regularly four times a day, for four months, from the 21st of February to the 22d of June, 1831, during which time they carried nearly 3,000 persons, and travelled nearly 4,000 miles. They performed the distance (nine miles) in fifty-five minutes, on an average, and frequently did it in forty-five. There were *sometimes delays* owing to defective pipes in the boiler, which prolonged the time, but no accident, hurt, or injury, ever happened to any person whatever; the engines were never out of order, and are as perfect now as they were at first. Steam-carriages can be worked profitably, so as to carry passengers for *one-half* of the prices at present charged by horse-coaches.

"Obstacles are always thrown in the way of a new invention, particularly if it is likely to produce important results, from the prejudices of those who have not fairly examined its merits, and by the opposition of others who expect *their interests* will be affected by its success. Thus objections have been made to these carriages, by various descriptions of persons, viz. country gentlemen, trustees of roads, farmers, coach-proprietors, coachmen, postboys, &c. &c. Some said they would be injurious to agriculture; others, that they would destroy the roads; others, that removing horses would ruin the farmers; and others, that it would ruin the coach-proprietors, and throw all the hands employed by them out of work. To these I replied, that the land which is used to keep one horse would keep eight people, and consequently, that the removal of one thousand horses would feed eight thousand people; that the cheap and expeditious mode of conveying passengers, and carrying every thing to market, would eminently tend to the *welfare of all classes*, agricultural and commercial; that the roads would suffer less injury from the broad wheels of steamers than from the horses' feet and narrow wheels of the present stage-coaches; that coach-proprietors would get more custom by carrying people at half the present prices, and would require less capital than in the present *uncertain* outlay for *horses;* and that coachmen, post-boys, and horsekeepers would also be benefited, as *more* men are employed about a steam than a horse-coach, in *addition* to the *increased* employment of artificers. The truth of these my arguments and opinions is fully confirmed and supported by the Report of the Committee.

"It will naturally be asked, if the coaches were successful, why they stopped running? I think this most important to be *truly* known to the public.

"I have given a general *idea of the opposition* which was made to our undertaking. Understanding that the trustees of the Gloucester and Cheltenham road were urged by the opponents of the undertaking to concoct measures for preventing the carriages running, on the 20th of June I addressed a printed letter *to the 'Trustees of the Gloucester and Cheltenham Road,'* pointing out the advantages to be expected from the introduction of steam-carriages, which I concluded with the following sentence:—

"'Having received encouragement from some of the leading members of the late and present Administrations, as well as from many distinguished persons in my own and other professions, I have come amongst you with the intention of establishing Mr. Gurney's invention, believing that it will be of the greatest benefit to the country. That it is daily gaining ground in public estimation, is evident from the *increasing number of passengers;* and I cannot believe that the enlightened body of gentlemen whom I now have the honour to address *will seriously resolve to obstruct* such an undertaking, sanctioned as it is by the King, and encouraged by the first people in the country.'

"This was on the 20th of June; on the 22d it was reported to me by my engineer, that large heaps of stones were laid across the road about four miles from Gloucester, eighteen inches deep! which the engine had passed over twice (in going to and returning from Cheltenham), with considerable difficulty; and that it was so unusual a mode of repairing a road (which was in excellent order, and required no repairs) that it must be a most serious obstruction to all descriptions of carriages[1]. The steamer was, in consequence of this difficulty, eighty minutes making the journey from Cheltenham with seventeen passengers[2].

"The steamer proceeded as usual to Cheltenham, in the afternoon of the same day, with sixteen passengers, and was again eighty minutes on the journey. On returning from Cheltenham with nearly the same number of passengers, the axletree broke about two miles from Cheltenham (before it reached the place where the stones had been laid down), which I attribute to the strain it had received in the morning from so unusual a resistance occasioned by the stones.

"It was represented to me by a great variety of persons, who offered to come forward if necessary, that the obstruction on the road was so great and so unusual to the stage-coaches, as well as carriages of all descriptions, waggons, carts, &c., and even the mail, that I was urged to represent it to the Postmaster-General to indict the trust, or to take some other legal mode of redress, against an act which was generally believed to be wilfully committed, for the purpose of obstructing the steam-carriages.

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[1] That it was an *unusual* mode of repairing a road is seen from Mr. M'Adam's evidence (Rep. p. 91), wherein it is stated, that "it is usual to abstain from all general repair of the roads from the middle of April to the middle of October;" and the inference we draw is, that it was also a *hostile* mode.

[2] "DEAR SIR, "*Gloucester, June* 23, 1831.

"I am exceedingly sorry to inform you that we have broke the hind axle. Yesterday morning we found the road filled up with loose stones for a considerable way near, the four-mile stone. The carriage with difficulty went through them, and also returned through them again without any mischief; but the third time the strain broke the axle between the throws. The horse coaches have been stopped in the stones. The clerk at the branch bank of England says, that he came across by the mail this morning, and that it was also stopped. Mr. Todd, of Cheltenham, says that he was obliged to get down from the coach he came to town by, and that the horses could not get it through. The Champion, from London, a fine four-horsed coach, was brought up, and, in whipping to get through, broke the harness to pieces. Waggons are obliged to get extra horses; in fact, the proceedings are most unaccountable. It is some relief, however, to know that the steamer has gone through where horses have been brought up; and I hope soon to get the axle mended.

"Many curious reports are abroad: it is said coach proprietors have done this; I am persuaded, however, this is not the case. Though interested men, they are far too respectable for an act of this kind. I believe there is no doubt who has been at the bottom of it.

"We have made altogether 396 regular journeys, making 3,644 miles in all. Our expenses in coke altogether 78*l*. One-third of this coke has been burnt in exercise and experiments when we were not running. I have taken the carriage to pieces to mend the axle, and find the engine not worn or injured; and, with the exception of the brasses on the crank, there has been no perceptible wear of any part. I am, dear Sir,

"Yours faithfully and obediently,

"*To Goldsworthy Gurney, Esq.*" "JAMES STONE."

"I was resolved, however, not to do any thing hostile, if possible; and felt only pity and contempt for those who could resort to such means for preventing a great national undertaking. But as I was convinced the public were daily growing more pleased with the conveyance, passengers from all parts of the kingdom declaring their satisfaction and cordial wishes for its success; and the lower classes expressing their conviction, that the substitution of steam for horses would tend to their comfort and relief, it was my intention to have strengthened my wheels, and to have gone on in spite of any obstructions. But, in the course of the following week, I learned that a vast number of Turnpike Bills had passed and that more were passing through both Houses of Parliament, granting tolls upon steam-carriages, which would be a complete prohibition; and that the Cheltenham trust was one of the number. Feeling that we were thus likely to be defeated by acts of the Legislature, in addition to the other difficulties, I relinquished my intention of continuing to run the carriages, and hastened to London, where I arrived in time to consult with you as to your petitioning Parliament, which led to the appointment of the Committee of the House of Commons. I remain, dear Sir,

"Yours most sincerely,

"C. W. DANCE."

"*To Goldsworthy Gurney, Esq.*"

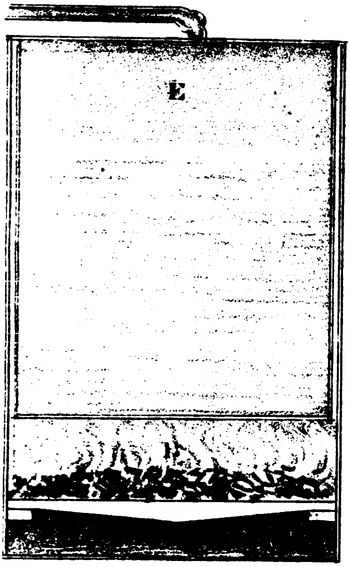
In a letter from Sir Charles's engineer it is said, "there has not been many minutes difference in the time of making each journey. I attribute the difference mainly to the different qualities of the coke, as I have had different mixtures of coals made into coke, in order to ascertain, if possible, which would answer the best; and partly to the different stokers having to keep up the fire. The time has been kept with the greatest accuracy; but I have only registered the passengers booked, and who paid fares: we took a large number who did not pay. We have charged less than one-half of the horse-coach fares for the last three months. This is a very bad place to commence on: we are surrounded with prejudiced people—agriculturists. Coach-proprietors, coachmen, stable-boys, and others directly or indirectly connected with them; these, with the old ladies of Cheltenham, I assure you, offer a formidable opposition to any innovation. Whenever we are a few minutes after our time, it is regularly reported we have either blown up or broke down, or both. I am happy to say, however, we have not met with the most trifling accident, up to this time."

Mr. Walter Hancock, in the summer of 1831, completed a carriage with which he carried passengers from Bow and Stratford to and from Mile-end Road, for a considerable period with success. A new one has now within a few weeks superseded it, which, from the size and power of the engines, and the general arrangement, there can be no doubt it will succeed.

The boiler is of a very peculiar nature, combining safety, economy of fuel and space, and providing an abundance of steam. Plate XI. shows an *elevation* of this boiler with part of the casing removed for the purpose of exhibiting the interior structure. A, one of the fire-doors, of which there are two. B, the fire-place. D, the stoke-hole. E E, the chambers, constructed of the best wrought-iron. F F, the manner in which all the chambers are bolted together, so as to form a large boiler of many compartments. On the plan of the boiler, the fillets of iron G G, which keep the individual compartments at a proper distance from each other. The spaces which these fillets leave are the flues of the boiler, through which, in the *section* of the boiler shown, the flame will be seen ascending as at H. All these compartments are connected at the bottom, for the purpose of keeping the water in each at the proper level; and at the top the steam is conveyed from each by as many pipes as there are chambers into the steam feed-pipe J, by which the steam is conveyed to the engines.

By this arrangement the only parts of the boiler which can be dreaded are the sides; but good ties will keep them together. And as to the bottom end and top of the boiler, which are composed of the edges of these compartments, if one part is burnt out or hurt, it is only that individual compartment which can burst, and its power of doing mischief is not worth notice.

Plate 11.



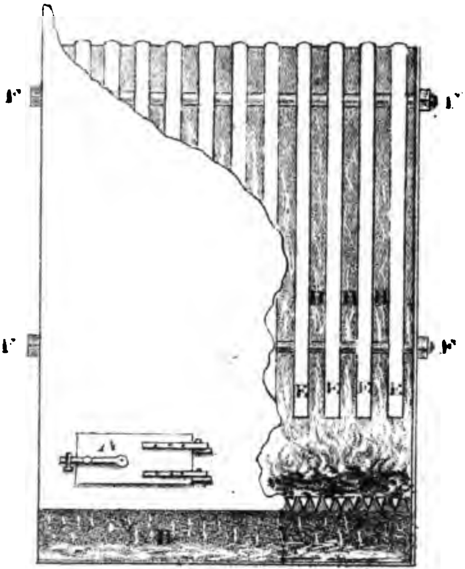
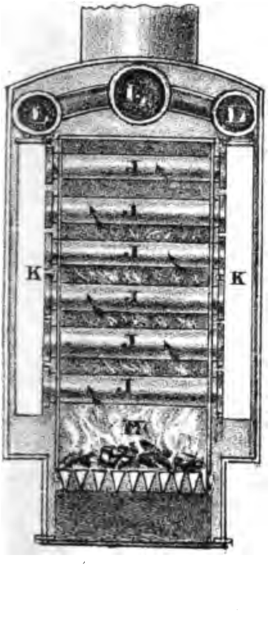
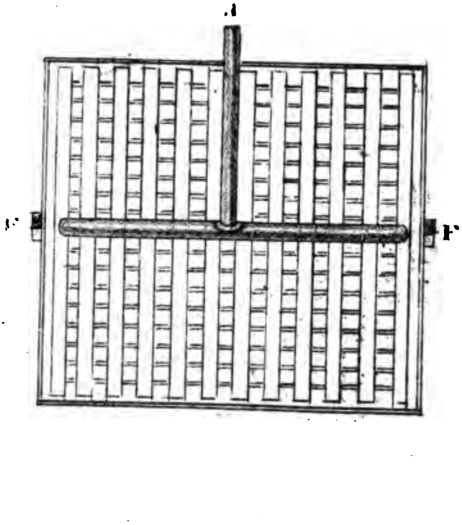


Fig: 1.





A. Gordon del.t et Lith:

Mr. Hancock's boiler may be relied on as safe, and its only effectual rival is Mr. Gurney's, in which the water is still more subdivided.

The engines in Mr. Hancock's new carriage are two. They are placed before the boiler, and are turned with the stuffing-box down, so that the cylinders are uppermost, and the pistons and correcting rods below. The crank-shaft with two cranks is supported by a flexible frame, which provides for any concussion on rough roads. A chain passes over a shive on the crank-shaft, and over a larger shive on the hind axle-tree. The wheels turn loose on the axle, and one or other, or both, are fixed by a clutch when required. This clutch is on the outside of the wheel, and can be screwed out or in, as the case demands, with great facility. The turning of the carriage round to the off-side is prepared for, by throwing out the off-side clutch, and keeping in the near one, and the turn-round to the near-side is prepared for, by throwing out the near-clutch, and throwing in the off-side clutch. A little play is left between the catches in each clutch, so that a winding road may not oblige either wheel to be disengaged; and it is only in a short turn, or a turn round, that the clutch must be shifted, and this can be done in a very small space of time.

The fire is urged by a blower, which is driven by a connection with the engines. The waste steam is blown from the engines into the chimney, and so destroyed. The provision for turning, being similar to others already sufficiently described, is not here noticed.

The passengers are carried on the same machine, Mr. Hancock preferring that disposal of the weight to the dragging of it in a carriage behind.

The wheels of this carriage are a beautiful exhibition of strength and lightness combined. The spokes are all wedge-shaped, and where they are fastened into the nave abut against each other. Their escape laterally is prevented by a large iron disc at each end of the nave; and these being bolted through, confine the spokesvery securely in their place.

In the Report, p. 32, Mr. Hancock's evidence is as follows:—

"There are flat chambers which are placed side by side, the *chambers* being about two inches thick, and there is a space between each two inches; there are ten chambers, and there are ten flues, and under the flues there is six square feet of fire, which is the dimension of the boiler top and bottom; the chambers are filled from half full to two-thirds with water, and the other third is left for steam; there is a communication quite through the series of chambers top and bottom; this communication is formed by means of two large bolts, which screw all the chambers together, the bottom bolts the bottom part of the chambers, and the top bolts the top part of the chambers, and by releasing those bolts at any time all the chambers fall apart, and by screwing them they are all made tight again; we have braces to fasten them; the steam is driven out from the centre of one of the flues, and the water is ejected from the pump at the bottom communication for the supply of water."

"Does the fire pass between the boxes, or does it pass through them?"—"It passes only between them."

"There is no line of communication for the fire made between the boxes?"—"Nothing more than the flue through which the fire passes; the sides of the boilers form the chimneys."

"Have you ascertained what pressure such boilers are equal to?"—"I have never gone beyond 400 lbs. on an inch; I have worked it on a road at 400; the average pressure on an inch is from 60 to 100."

"At what pressure do you set your safety-valve?"—"Taking the average of roads, I work at about 70 lbs. upon the square inch."

"You have calculated how many square feet of boiler?"—"At the present carriage I have 100 square feet of boiler exposed to the fire."

"What distance do you run from stage to stage?"—"What I consider the stages I have run is four miles; but every eight miles I take in water; I go there and back."

"You consider your stage eight miles?"—"Yes."

"Do you take in both water and fuel at the end of a stage?"—"Yes, at the end of every eight miles."

"What quantity of water and what quantity of fuel do you use for each stage?"—"About 7 cwt. of water, and sometimes eight; it depends upon the roads; we consume more steam when the roads run heavy."

"How much coal or coke do you use for each stage?"—"About two bushels of coke."

"Do you mean that you take two bushels at the commencement of each stage?"—"I take more with me, but I always consume a quarter of a bushel per mile."

"You do not in that include your first charge of coke when you set off?"—"No, that would vary according to circumstances: if I were in a hurry, I could get the steam up in five minutes; but the average time is about twenty minutes in getting up our steam, and we do not consume more than a bushel."

"That is at first starting?"—"That is at first starting."

"Do you apply a second carriage to your engine for passengers, or do you carry them in the same carriage?"—"The boiler is placed behind the carriage; there is an engine-house between the boiler and the carriage; the engines are placed perpendicular between the passengers and the boiler, and the fore part of the vehicle is for the passengers, so that all the machinery is quite behind the carriage, and the fore part of the carriage entirely for the convenience of passengers."

"Where does the guide sit?"—"In the front, the same exactly as a coachman in a common stage."

"How many passengers have you carried?"—"We carry ten; but I am making provision to carry fourteen."

"What is the weight of your vehicle?"—"I should imagine about three tons and a half."

"Have you ever weighed it?"—"Not this carriage; but the carriage I had before, the vehicle itself with the engines and boilers, weighed three tons; I consider the present carriage to weigh from three tons to three and a half tons, with fuel and water."

"Have you found the rate of tolls that have been charged at the turnpike-gates very high?"—"On the City-Road toll I have paid a shilling; I do not know whether it is according to proportion, for it was a thing that did not embrace my attention at that time; but the highest toll that I have paid is a shilling; but on the road that I run from Stratford to London they told me they would not take it; they would take it another day."

"What effect do you think your carriage has upon the road, in proportion with a carriage equally loaded, with four horses?"—"I think, myself, we should rather improve the roads by the operation of our engines, because a steam-coach requires broad wheels, perfectly upright and flat on the outside of the tire."

"What is the breadth of the tire?"—"The tires of the present wheels are about three inches and a half."

"What is the diameter of the hind wheels?"—"Four feet. That is not a propörtion that I consider to be working as a profitable diameter; I consider that the diameter that should be used for a steam-coach is at least five feet."

"How wide could you make that tire without losing power?"—"It depends on the weight; but taking the common coaches, I should say from six to eight inches."

"Without injuring the power?"—"I have no doubt it would be no drawback on the power."

"Do you consider that such breadth would be as good as any other, the best you could make?"—"Yes; because a broad wheel on gravel is considered to be a great advantage; it is a great disadvantage on a road which is between wet and dry; but in those cases we have always an overplus of power blowing off at the safety-valve, and from that circumstance I am rather pleased at having rather a dead road to run upon, because we are obliged to construct the vehicle so as to overcome all obstacles in the road, such as dead gravel, &c."

"To how many of your wheels do you apply your power?'—"To two; occasionally one."

"Do you apply it to a crank?"—"The axletree of the present carriage is made precisely the same as the common axles now in use, straight and merely bent at the end, and I have a chain which I put on the nave of the wheel, and that communicates with a corresponding chain-wheel on the crank-shaft of the engines."

"What is the size of the circle on the wheel to which you apply your chain?"—"About ten inches."

"How wide is the corresponding circle on the crank-shaft?"—"The corresponding pulley of the shaft is just the same; so that the power of the engine is the same exactly as though it were applied to the wheel itself."

"You have two wheels; how do you move the first wheel?"—"There are two engines working on two cranks, exactly on the same principle as used in common for steam-coaches; I take the chains; I place the engines four feet from the axletree of the hind-wheels, and the communication of the chain is to allow me to put my work on the springs, and the play of the carriage up and down is accommodated by the chain."

"Is your cylinder on springs?"—"Yes, every thing on springs."

"Do you make use of one or two cylinders?"—"Two."

"What size?"—"Twelve inches in the stroke, and nine inches in the bore."

"Has your engine met with accidents?"—"No, except once I broke my chain; but in the course of five minutes we could replace that chain, by taking an extra chain with us."

"Are your boilers easily cleaned?"—"In all the experience I have had with the working of boilers, I have found that they never require cleaning. I consider that the ebullition is so rapid, and the action of water so violent, that it will not allow any dirt to fix."

"How long do you calculate one of your boilers would last?"—"It depends upon the thickness of metal. The boiler we use I consider will last, in locomotive engines, from a twelvemonth to two years."

"What is the thickness of the iron that you use?"—"I should suppose about the eighth of an inch thick."

"Of what material are they composed?"—"Of the best charcoal iron."

"What is the appearance of your carriage; has it an unsightly appearance?"—"I think my present carriage is any way from being handsome, because it has been built entirely for experiments."

"Does the chimney rise above the carriage?"—"No, you cannot see the chimney."

"When steam is let off, where is it let off?—"You can see nothing of it."

"Then there can arise no annoyance either from smoke, or from waste steam?"—"None at all."

"Do you find that horses are frightened by your carriage?"—"I think I may say safely, that not one horse in a thousand will take the least notice of it; occasionally a horse may shy at it. I have seen fine blood-horses come along, and shy at a wheelbarrow lying in the road, and not shy at my engine. There is one very curious instance which once occurred, and I was obliged to the gentleman for the pains he had taken. He had a fine horse on the road, and this horse shyed; he was determined to get over the difficulty, if it were possible; and to make him acquainted with it, he came with the engine to town; and at last, when we got to London, the horse got quite tranquil, so that he put his head in the engine-house, which is very uncommon, and which is a thing I never saw a horse do before."

"Then you anticipate that if such engines become more common, there will be less difficulty in this respect?"—"I have no doubt of it."

"Does it produce any very extraordinary noise in its motion?"—"We have worked so quietly latterly, that I have almost run over people on the road, and they have not heard me; I have had to halt very often; they have not been aware of the coach coming."

"Under any circumstances, the noise that is anticipated would take place from the defect of the machinery, and not from the machinery itself?"—"Yes; we make one-third of the noise of a common-stage."

"When you let off steam, does it produce any violent noise in stopping?"—"I can give an instance to the contrary which occurred in London, which is the best place to put the thing to a test: about a fortnight or three weeks ago, Mr. Wilks was kind enough to mention my running on the Stratford-road, and I wished him to present a petition from me to the House of Commons, and at the same time requested that he would take a ride with me in my engine on the Stratford-road; I waited three-quarters of an hour for him, and the machinery was working the whole of the time; there were hundreds of people walking round it, and I suppose they did not know it was working at all; there was no noise at all in the machinery; and you could not, unless you had gone to the back, know that it was working."

"Does spare steam pass off without noise?"—"Not any."

"Supposing that you were going at full work, and that you had occasion to stop for a passenger, you would be obliged to let off steam?"—"Yes; but knowing from experience how to obviate a disadvantage of this kind, which of course practice alone has brought to bear, it is probable that a stranger would hardly know it, it is so quiet."

"In what part would it be thrown off?"—"It is divided and thrown off from the fire in every direction, and it is instantly consumed; the force is spent."

"Is not that rather a dangerous experiment, to throw a great body of steam upon a confined fire?"—"No, we have never found any disadvantage from it."

"In no circumstances in which the engine may be at work, have you to let off steam in a way to create a noise?"—"No; the boiler will not hold any quantity of steam; we let off steam from the safety-valve as fast as we make it; there is no capacity for accumulation; the fault of many of the boilers is, that if any accident happens there is a complete explosion."

"Then, of course, the danger is lessened?"—"Yes, to construct a boiler of that kind has been my object, so that the steam may be let off."

"Suppose if one of your boilers were to burst, what would happen?"—"I will give the committee an instance. I was travelling about nine miles an hour at the time the boiler was the twenty-fourth part of an inch thick. I was working then at 100 lbs. on the square-inch with thirteen persons on the present vehicle that I have now in use, and all of a sudden the carriage stopped, and for what reason I was at a loss to know; I got from my stage-seat and went to the engineer to ask him what was the reason he had stopped the steam; he told me he had not stopped the carriage, and he immediately applied his hand to the gauge-cocks; I found there was neither steam nor water in the boiler. I immediately knew that the boiler was burst; they said they did not know it, as they heard no noise, and I told them that I did not mean they should know it. I said I would show them that it was so, and I took the boiler from the carriage and unscrewed it, and there were four large holes that I could put my hand into. This occurred from the chambers being too thin, and they drove all the water out of the boiler, and yet there was no injury to any person; there was not one person that heard any report; there was no steam, and there were no symptoms in any way that the machine itself had burst."

"Do your boilers extend under the place where passengers sit?"—"No, quite at the back."

"What is the length of the carriage?"—"About sixteen feet, and the room the boilers occupy is about three feet."

"Are the chambers of the boiler placed upright side by side?"—"They are placed sideways."

"In what circle could you turn your carriage?"—"The circle of the inner wheels would be four feet, and the outer wheel would exceed that by the breadth between the wheels; taking the average it would be ten feet."

"Supposing you wanted to turn round, what should you do?"—"If I got into any difficulty, and wished to go back, by applying my hand to the lever, I should reverse the motions and run the reverse way."

"Supposing that you are travelling in a street of ten feet wide, and that there was another street of ten feet wide branching off at right angles with the first street, would there be any difficulty in turning into it?"—"Not any, but I could not turn round in that street. In that case I should back the engine."

"Would you check your speed?"—"That would depend upon the speed I was going at. If I was going at six miles an hour, it is probable that I should not check the speed; but if I were going ten miles, it is probable that I should before I turned round into the street."

"Are your fore-wheels and hind-wheels the same diameter?"—"The fore-wheels are three feet three, and the hind-wheels are four feet."

"Can you reverse the action of your carriage with great ease?"—"Yes; by simply pulling a lever, it is done momentarily. In my present carriage I could not; but I have an arrangement of that kind in the other carriage which I am making."

"Supposing you were going at the rate of eight miles an hour, and that you wished to stop suddenly, in what number of feet could you stop your carriage?"—"I will say twelve feet."

"Of course there is equal facility in avoiding any particular object on the road?"—"Yes."

"In stopping so suddenly, would there not be a danger of your being thrown off?"—"No, I think not."

"Have you ever done it?"—"Yes, I think I have."

"Supposing that you wanted to stop in the quickest possible way, at what distance could you stop at that rate of speed?"—"About four feet, I should think, by backing the engines, because it is like putting a block to the wheel."

"Would there be no danger in that?"—"No, I think not; it would throw a strain on the engines; the rate of eight miles an hour is not so great; it is only in extreme cases that that would be done. I am very frequently obliged to pull up very short, from children running in the road."

"Of what materials are your wheels made?"—"Like common dished wheels, they ought to be perfectly cylindrical. I merely took them to avoid expense; they were wheels which I had by me."

"Are you proprietor of any other coaches?"—"No."

"Have you any means of ascertaining the proportion of friction that there is on your wheels, and those drawn by horses?"—"No, I have never gone into experiments to any extent upon that point."

"Are your wheels shod frequently?"—"No, I have never had occasion to have the wheels shod; they were not worn out."

"For what number of miles could you run without being obliged to shoe your wheels?"—"I do not know."

"Do you find any difference of wear between your propelling-wheels and your drawing-wheels?"—"No, except in relation to the weight on the hind-wheels. We throw more weight in order to produce friction, to get adhesion to the ground."

"Have you turned your attention to the improvement of your machine, by affixing a carriage to it, and making your engine independent of the carriage?"—"Yes; I have considered the thing well in every point, and I think it is much better to construct the carriage both for passengers and machinery on one arrangement, not to have the thing divided: my reason for considering it an improvement is this; for instance, if a new road is made, the object of the proprietors of that road is to get as heavy a roller as they can, even if it requires eight horses to draw the roller; they do that in order to imbed the gravel to make it solid, and the nearer that steam-coach approaches that roller, the better it is for the propelling-wheels."

"Have you made any calculation as to the number of horses that the extension of these carriages will displace with respect to each stage; what horse-power is equivalent to the carriage that you run?"—"I take a stage to run 100 miles a day, and I reckon upon the average it would take from 48 to 50 horses for the whole distance; the common average is a horse a mile; but from the information I have endeavoured to get, from what I have gathered, I find it is about 48 or 50; I believe it is to be taken backwards and forwards at a horse a mile."

"Would your carriage displace along the road four horses on each stage?"—"Two ten-horse engines would displace the whole number of horses along the stage."

"Have you made experiments which enable you to answer these questions?"—"I was not at all prepared; my principal object has been to ascertain what power I have to do a certain work; I have paid very little attention to horse-power."

"Do you think that your carriage is equivalent to a four-horse carriage on the road, in the number of persons it would draw?"—"It is more than equivalent to it, from the circumstance of its being able to do more work."

"Supposing you have to run seven miles, how many passengers could you carry at your present speed?"—"Fourteen."

"Supposing that a coach of four horses were to run that seven miles, how many passengers would it take?"—"It would carry the same number."

"What weight, upon a dead level, will set your carriage in motion on the road if you were to attach a rope to the pole, and suspend that rope over a pulley, and attach a weight to it, what weight will set your carriage in motion?"—"It is an experiment I have never tried, and I am not prepared to answer."

"Do you know what, if you were to set your carriage on an inclined plane, is the inclination that will set it moving?"—"No, that is not a thing which I have tried."

"Do all the wheels follow in the same track?"—"Yes, they do."

"Have you ever tried your carriage up hill on an inclination?"—"Yes, I have, repeatedly."

"Do you find an increased difficulty in proportion to the length of the inclination?"—"No, we go much slower; but we never find any difficulty."

"Have you ever found your wheels slip?"—"No, excepting once on the City-Road, at the time when the frost was on the road; it was quite slippery; and then, for an experiment, I tried to see if I could run up the Pentonville-Hill with one wheel only, and I did, but it was with some difficulty towards the top; if I had propelled by the two wheels, there would have been none."

"Have you found at what inclination in a frost the wheels will begin to turn?"—"I never witnessed such a thing."

"Are you aware that such a thing will occur?"—"Yes; but I think there are no hills which are to be found, upon which horses travel, but what a coach would propel itself up."

"Have you ever seen your carriage get into a deep rut?"—"Yes."

"In such a case what generally happens?"—"If it is a single wheel, it may go round two or three times; if I have two wheels, it is improbable I should get into such a situation."

"Do you find peculiar states of the roads upon which you travel more disadvantageous than others to the progress of your carriage?"—"Yes."

"Which do you find the most disadvantageous?"—"When the roads are between wet and dry."

"In going down a hill, are you obliged to lock your wheel in any way?"—"Yes, if it is much down hill; it depends upon its inclination."

"What is the nature of the provision for locking the wheel?"—"A metallic band, bearing upon the outer part of the wheel."

"What are the fares that you take, higher or lower than ordinary stages?"—"They are the same fares as the stage fares, eight-pence from Bow, and nine-pence from Stratford."

"How much is that a mile?"—"Barely two-pence a mile."

"In what proportion to what is charged by stage-coaches do you think you should be able to charge your fares?"—"I think the fares would be reduced to two-thirds, after a short time, if supported, and not over-burthened by tolls."

"Should you be able to continue running if the fares were reduced to two-thirds?"—"Yes."

"In your present state of knowledge upon this subject, in what proportion do you think the rate of travelling would be diminished?"—"In the proportion I have stated of two-thirds."

"Is it your opinion, that, generally speaking, it would be reduced two-thirds?"—"Not in the outset, but after the thing has had full play."

"Have you made any calculation of the expense of running a coach drawn by four horses, carrying a certain number of passengers, and that of running with one of your carriages at the same velocity?"—"I have endeavoured several times, but I have never been able to get an accurate account of the power and other expenses incurred in driving a long stage; but I reckon my own expenses will cost from three to four pounds a day, including all expenses attached to the coach, wages for engineer, steersman, fuel, oil, &c."

"What expense is it a mile upon your coach?"—"I have taken the one hundred miles, and included the day's expenses."

"Were you ever a stage-proprietor yourself?"—"No."

"Then from your own knowledge you can state nothing as to the cost of carrying passengers by a stage-coach?"—"No."

"Could you, if you were to travel one hundred miles in ten hours, keep up that rate without damage to the machine?"—"Yes, I reckon the work would be done in eight hours, but the stoppages and one thing and another will take up two hours."

Mr. Farey's farther evidence of this engine (Report, p. 49,) is as follows:—

"Were you ever in Mr. Hancock's carriage, when travelling?"—"Yes; I have ridden on it; but he has put in larger cylinders since I went with him the last time, and I understand makes better progress now. I have examined all his present machinery in detail, and think it very judiciously planned."

"Did you find that it frightened horses, or annoyed passengers?"—"I have stated before, that I found horses were not frightened; but every one must judge for himself of the degree of annoyance he experiences. Persons who are accustomed to travel in luxurious private carriages would find many annoyances in a common stage-coach, which others would consider as excellent travelling. I am so accustomed to machinery, and to stage-coach travelling and to steam-boats, that I am not liable to be annoyed thereby; and I found riding in Mr. Hancock's carriage to be exceedingly like travelling in a stage-coach. I heard no complaints by passengers. I believe he has never found any difficulty in getting passengers, since he has run for hire. Persons are reported to be annoyed by the smell of hot grease, in the steam-coaches on the Cheltenham road; I can only say, that I never observed such a smell in Mr. Hancock's carriage. If there are any real annoyances to the passengers in particular steam-coaches, they will work their own cure in a short time, either by the proprietors finding out remedies, or else giving up their coaches, as they must do if they are not rendered agreeable to the passengers. The only question that deserves attention is, whether there is any danger to passengers, or any serious annoyance to other persons not passengers."

"Did you observe any horses or carriages passing his carriage?"—"Yes, I have always passed through crowds of horses and carriages with all the steam-coaches I have tried; there is so much curiosity excited by the novelty of a steam-coach in motion, that all the horses on the road are drawn up to get a sight of it, and many are turned to follow after it. I have observed that some horses take very little notice of the steam-coach; others are a little startled, but I never saw any difficulty which the reins could not control with the greatest ease; horses are easily alarmed at any thing unusual, but they very soon become accustomed to any thing, as is shown by the readiness with which horses can be brought to endure discharges of fire-arms and of artillery. A patent was taken out some years ago for what was called a Travelling Advertiser; it was a small four-wheeled carriage, supporting an enormous octagonal tower, which was stuck all over the outside with printed bills for advertisements; it was drawn very slowly through the streets by one horse, and had a most unusual appearance: this machine was indicted as a nuisance because it frightened horses."

"Have you never observed horses to shy at a stage-coach when heavily laden?"—"I have observed horses to be alarmed at the enormous bulk which some of the vans carry at times at a great height above ground; horses are the most timid animals to encounter every thing that they are not accustomed to, and the most courageous animals to encounter every thing that they are accustomed to, even when really terrific, such as discharges of fire-arms."

Messrs. Summers and Ogle are now engaged making experiments with a locomotive-carriage, undert heir patent, at Southampton. I was politely furnished by the patentees with a perspective drawing of this engine, but am unable to furnish a drawing, as their more perfect description has only arrived as this sheet is going to press. In order, however, to give information from an authentic source, I quote from the Report of the Committee of the House of Commons.

Mr. Nathaniel Ogle in his examination, (Report, p. 69,) gave evidence as follows:—

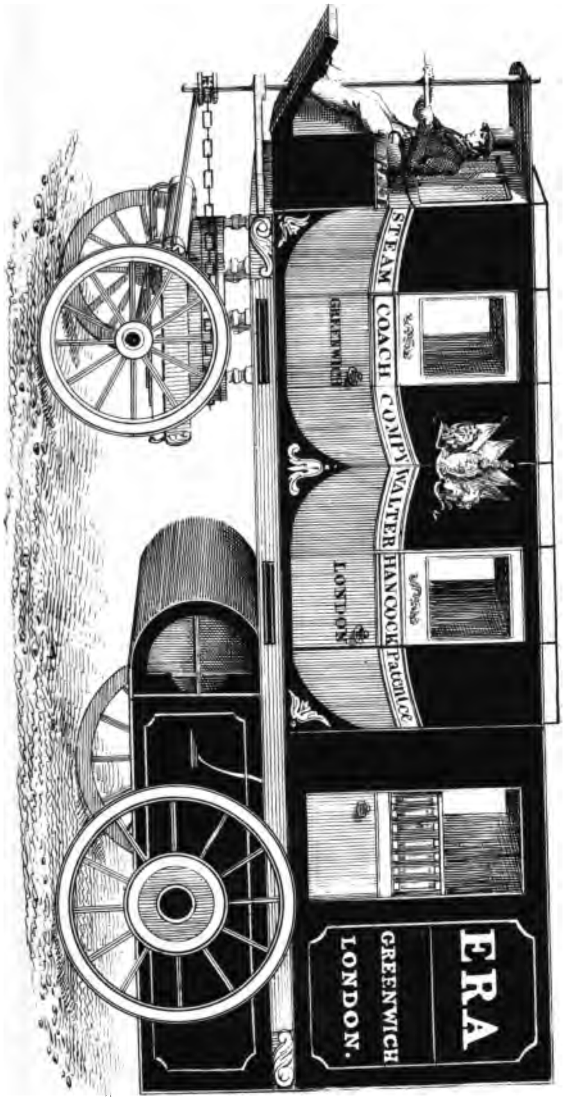
"What is your profession?"—"I have no profession; I am pursuing the introduction of locomotive-engines on common roads."

"Have you invented any carriage of this description actually now in practice?"—"Yes, partly so."

"Have you run your carriage for any length of time on public roads?"—"About eight hundred miles, or rather more, over roads of various descriptions, and up lofty hills."

"Will you describe generally the nature of your carriage, and of any improvements you have made, since you first turned your attention to the subject?"—"The object in all locomotive vehicles is to obtain a mode of generating steam that shall give the command of a sufficient power, under all varying circumstances to be met with on the common roads. We have obtained that desideratum, by combining the greatest heating surface in the

Pl. 12.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least possible space, with the strongest mechanical force, so that we work our present boiler at 250 lbs. pressure of steam on the inch, with the most perfect safety. Our experimental vehicle, weighing about three tons, or rather more, we have propelled from London to Southampton, and on the roads in the vicinity of Milbrook, at various speeds. The greatest velocity we obtained, over rather a wet road, with patches of gravel upon it, was between thirty-two and thirty-five miles an hour. We have ascended a hill with a soft wet bottom, rising one foot in six, at rather a slow rate. We have ascended one of the loftiest hills in the district near Southampton, at sixteen and a half miles an hour. We have gone from the turnpike-gate at Southampton to the four-mile stone on the London-road, a continued elevation, with one very slight descent, at a rate of twenty-four and a half miles an hour, loaded with people. The locomotive vehicles used on the Liverpool and Manchester rail-road would not go at three miles an hour on a common level road, and would not ascend any hill; and on account of the diameter of their boilers, cannot, scientifically speaking, be considered safe. The vehicle is under perfect control in every respect. No accident from explosion can take place. We have had whole families of ladies, day after day, out with us in all directions, and who have the most perfect confidence."

"Will you describe the form of your boiler?"—"The base of the boiler and the summit are composed of cross pieces, cylindrical within, and square without; there are holes bored through these cross-pieces, and inserted through the whole is an air-tube. The inner hole of the lower surface, and the under hole of the upper surface, are rather larger than the other ones. Round the air-tube is placed a small cylinder, the collar of which fits round the larger aperture on the inner surface of the lower frame, and the under surface of the upper frame-work. These are both drawn together by screws from the top; these cross-pieces are united by connecting pieces, the whole strongly bolted together, so that we obtain in one-tenth of the space, and with one-tenth of the weight, the same heating surface and power as is now obtained in other and low-pressure boilers, with incalculably greater safety. Our present experimental boiler contains 250 superficial feet of heating surface in the space of 3 feet 8 inches high, 3 feet long, and two feet 4 inches broad, and weighs about 800 weight. We supply the two cylinders with steam, communicating by their pistons with a crank-axle, to the ends of which either one or both wheels are affixed as may be required. One wheel is found sufficient, excepting under very difficult circumstances, and when the elevation is about one foot in six, to impel the vehicle forward."

"You state that the weight of that carriage is about three tons or more; is that independent of the necessary load?"—"That will include the coke and the water, but not the passengers."

"Have you any peculiar means for rendering explosion impossible?"—"Yes; the cylinders of which the boiler is composed are so small as to bear a greater pressure than could be produced by the quantity of fire beneath the boiler, and if any one of these cylinders should be injured by violence, or any other way, it would become merely a safety-valve to the rest. We never with the greatest pressure burst, rent, or injured our boiler, and it has not once required cleaning after having been in use twelve months."

"At what pressure do you usually work your carriage?"—"Two hundred and forty-seven pounds on the square inch of the boiler, but we have worked it at a greater pressure than that."

"To what pressure do you usually weight your safety-valve?"—"Two hundred and forty-seven pounds."

"Then you travel always on the lift?"—"Yes; we are always glad to see our steam blowing off, and when our fire is even moderately good, it is always blowing off, even up the steepest hills, proving an excess of power."

"Does that create any annoyance to passengers along the road?"—"None whatever; the waste steam is carried round a double casing of the fire-place, then brought over the surface of the fire, where some portion is consumed, and the rest passes off through a very small chimney in an aeriform state."

"Do you use coal or coke?"—"Soft and good coke, which easily ignites and burns rapidly."

"You have not any annoyance then to passengers from smoke from your carriages?"—"None whatever; there is no appearance of smoke except on lighting the fire with wood, which is necessary to ignite the coke."

"That takes place before you start?"—"Yes; but even that will not be necessary when every thing is arranged."

"You state that your carriage is under the most perfect control?"—"Perfect."

"Supposing you were going at the rate of ten miles an hour on a level road, in what number of feet do you suppose you could entirely check the carriage?"—"It would be difficult to state precisely the number of feet, but certainly in a less space than you could stop a pair of carriage-horses going with the same weight attached to them. I have no hesitation in saying, that a steam-vehicle is safer in every respect than one with horses, that it is under more complete management at the same velocities and with the same weight, that it is more easily controlled, and that none of the accidents from fractious horses can take place with steam-carriages."

"Do you find that horses are generally frightened by passing your carriage?"—"Very few indeed; persons usually alarm their own horses (the animal being quickly subject to alarm) either by dismounting, or patting them, and thus anticipating apprehension."

"How many wheels have you?"—"Our present carriage has only three, so that the centre-wheel rolls that portion of the road which has been cut up by the action of the horses' feet."

"Is it of the same breadth as the two hind ones?"—"It is broader, being four inches and a half."

"Is the centre wheel a guiding wheel?"—"It is."

"What portion of weight is upon that as compared with the others?"—"That must vary a little, but generally about one-third."

"Is yours a coach?"—"No, it is a treble-bodied phaeton."

"How many passengers have you carried when you have gone at the rates you have described?"—"I think I have seen nineteen; weight is of no importance to a steamer."

"Taking the weight of your carriage, with the engine, at three tons, what weight do you suppose that you could carry at the rates you have spoken of?"—"Between three and four tons, very well."

"Besides its own weight?"—"Yes."

"Doubling its own weight?"—"Yes; twenty people will weigh more than a ton and a half."

"For what distance do you travel without taking in water?"—"We can increase our capability to a great extent; at present, we carry about seven hundred weight of water; it lasts about forty minutes; that depends on the quality of the road."

"How much coke?"—"The quantity we carry is according to the distance we wish to go."

"What weight of fuel would you think it necessary to take in, to go one of your average stages?"—"Three bushels."

"How much does a bushel weigh?"—"That is difficult to answer; coke differs in its weight: the average weight is about forty pounds a bushel."

"Are your wheels dished, or are they cylindrical?"—"Cylindrical, with flat tires."

"What are the diameters of your propelling wheels?"—"We have generally used them about six feet; those we have now are about five feet six."

"Have you changed the diameters from experiment, from finding the smaller diameter more convenient?"—"From finding some wheels with the spokes cut through, whether intentionally by the workmen, or from mere neglect, we could not tell; but they were merely reduced from six feet to five feet six."

"For a carriage calculated to carry eighteen persons, what would be the length, and what the breadth?"—"I think that our next will measure eighteen feet six; that is not so long as a carriage with two horses: the breadth six feet nine inches between the wheels."

"In the improvements you are now engaged upon in your carriage, are they relative to the size and weights of the different parts, or merely in the conveyance of the goods and passengers?"—"They are more in improving slight details; the power we have, beyond all question, to propel vehicles of any weight, at any required velocity."

"Have you made many experiments as to the size of your cylinder?"—"We have made several experiments."

"In reference to the usual velocity you require, and the weight you have to carry, what do you find the most advantageous size of cylinder?"—"The larger the cylinder, certainly, the better."

"What is the greatest weight that any steam-engine you have ever built is capable of carrying ten miles an hour?"—"About three tons, in addition to its own weight."

"Have you ever ascertained that that carriage, when loaded, weighs six tons?"—"No, never."

"What was the greatest weight you ever weighed?"—"We never weighed it at all. I can only speak from conjecture. I have seen nineteen persons on it, and seven hundred weight of water."

"At what rate did you travel with that load?"—"We went with that load up a considerable ascent, about thirteen miles from Southampton, I should think, about from a quarter to half a mile. We travelled about ten miles an hour."

"How did you ascertain that rate; did you make accurate observations at the time?"—"We know pretty accurately, by observation, at what rate we are going; but we can ascertain with the greatest minuteness, by knowing the number of revolutions made by a wheel of a certain diameter."

The speed these engines are said to have gone at, should be judged by measurement of the road, not by conjecture or calculation. The speed of a body in motion is always difficult to determine. It cannot be judged of with accuracy by merely counting the strokes of the engine, when a carriage is flying along at this rate, of a mile in two minutes, even supposing the patentee's calculation to be correct. There is a very great probability that the speed of the engine may not be properly counted, and I am very much inclined to think the wheels at that speed may travel through thirty miles, whilst the carriage will not pass over twenty-five miles, because the great speed of the engine may not have time for the wheel to hold the ground. The greater the speed of the carriage the less the weight bears on the point of impulse; this lessens the hold of the driving-wheel on the road, and hence it may travel thirty or more miles skiffing the ground, whilst the carriage is only made to travel twenty-five or fewer miles.

"When you were conveying those nineteen persons, how many horse power do you suppose was exerted by your machinery?"—"Nearly twenty-horse power."

"You have stated that your carriages do not do injury to roads, but are rather a benefit; subsequently you have said that your carriages did not do half the injury of common carriages?"—"Yes; if the tire of the wheel was very broad it would be no injury."

Mr. William Alltoft Summers called in, and examined.

"Are you practically acquainted with the operation of steam-carriages on common roads?"—"I am."

"Have you ever superintended the building of steam-carriages?"—"I have superintended the building of two steam-vehicles."

"In the present carriages which you run on the Southampton-road, what is the size of the cylinders?"—"Seven inches and a half diameter each, and the stroke of each piston eighteen inches."

"Do you apply your power immediately from the piston to the crank?"—"Through the medium of a connecting-rod only."

"You have stated that you went up at the rate of fifteen miles an hour; how did you make that calculation?"—"By counting the number of revolutions made by the hind wheels."

"Are you quite sure there was no loss from slipping during that period?"—"I am quite sure there was no loss."

"Having ascended the most difficult part at the rate of fifteen miles per hour, and placing your mean power at so low as ten miles per hour, and stating the reason of the mean being so low that the fire was in better order at one period than another; does it proceed from any defect in your fire-place which renders it difficult to keep the fire always at a certain power?"—"At that time we had not the means of stoking or putting fuel on the fire through the centre of the boiler, the consequence of which was, that we were obliged to put a greater quantity of fuel on the fire than we otherwise should have been, which caused the fire to be a considerable time before it burnt through the fresh fuel; but having lately made a trifling improvement in our boiler, we now average with the present vehicle fifteen miles per hour."

"Were you travelling for hire on that road?"—"We have never travelled for hire yet, but merely on experimental journeys."

"What distance have you ever continued travelling at the rate of thirty miles an hour?"—"We have continued travelling at the rate of thirty miles an hour, four hours and a half very frequently, and could have continued to have gone longer had we not required a fresh supply of water, our tank being not quite large enough."

"How could you continue to travel at the rate of thirty miles an hour, when you have already given so low a mean of the average of travelling on account of your fire-place?"—"Because it depends entirely on the quality of the fire; we have never found any difficulty in travelling over the worst and most hilly roads since our last improvement in the furnace, when the fire is in good order."

"By what operation do you decrease the velocity of the carriage going down the hill so as to check the inclination of itself to run down the hill, and yet keep it under control?"—"On arriving at the brow of the hill we throttle or wire-draw the steam in order to check the velocity of the engines; and if we find that the hill is so steep that the carriage would run faster than we wish, we have two drags attached to the hind wheels, and with the foot we press on one drag or on both, as it may be required, and by that means regulate the velocity of the carriage."

"Does not that stop the motion of the wheel?"—"No, it does not prevent the wheel revolving."

"How is the drag applied?"—"It is a kind of iron band or strap which goes round a portion of the tire of the wheel, and our power of breaking is multiplied by levers to a very great extent."

"How often do you find it necessary to clean your boiler?"—"We have never found it necessary to clean it yet; it has been in operation more than twelve months."

"Do you conceive that it is owing to the peculiar quality of the water, or that under any circumstances that would happen?"—"We have had water of every description."

"Is there no incrustation upon it?"—"Not the slightest."

"Supposing there were incrustation upon it, would it be difficult to clean it, and would that require an engineer?"—"It would merely require a common labourer to clean the boiler, which might be done by removing some plugs that communicate with each of the cylinders of which the boiler is composed, and when required may be done with a scraper or wire-brush."

"What becomes of the carbonate of lime and the sulphate of lime, and so on, which are in solution in different waters?"—"Every time after we have arrived at our journey's end, we open a cock communicating with the bottom of the boiler; perhaps we do not give the matter time enough to rest; it is all blown out at the pressure of 240 lbs. on the square inch."

"Have you ever had your boilers rent?"—"No, we have never had an instance in which the boiler has given way in any part of it, and in several instances we have had it red hot."

"Of what material is it formed?"—"Of the best charcoal iron."

"Have you ever tried it by pressure?"—"I proved the boiler before it was put into the steam-carriage at 364 lbs. on the square inch; it will support 740 lbs. on the square inch."

"At what pressure do you work?"—"We usually work it on the road at a pressure between 240 and 260, finding that pressure more economical than any other."

"What is the thickness of the iron?"—"About one-tenth of an inch: thin boilers last longer in proportion than thick ones, because the heat sooner passes through into the water, and has not time to act upon the iron."

"For what period do you conceive that it is calculated to last?"—"From having had twelve months' experience, I should say it would last very well two years and a half."

"During what portion of the twelvemonth was the engine in actual operation?"—"It has not been in constant operation every day; but we have been in the habit of going out four days out of six, and working from eight in the morning till seven or eight o'clock at night; the boiler is not at all injured, it is in the same state in which it was when first put into the vehicle; neither have we had any accident with the machinery, contrary to the opinion of almost every engineer who saw the vehicle before it left London; the vibration or jar being much less on common roads than on a rail-way, and the whole of our machinery being suspended on springs; the engines work as smoothly as if they were fixed on the firmest foundation."

"Where are the passengers placed, in reference to the boiler?"—"They are placed in front and in the middle of the vehicle, and the boiler is entirely behind the body of the carriage and the passengers."

"You are frequently in the habit of passing horses?"—"Yes."

"Do you find that they are frightened?"—"I have occasionally observed them shy, as they sometimes do at a wheelbarrow; but we never had any accident from horses being alarmed."

"Is there a peculiar noise attends the motion of your engine?"—"The noise is not so great as in a vehicle drawn by horses."

"It has been stated to the committee, that in some steam-carriages actually in operation there is a very peculiar noise from the escape of the steam; from whence does that proceed?"—"It proceeds in one carriage, which I have seen running along the roads, from the steam being blown in at the bottom part of the chimney of the furnace, at a distance very near to the open air."

"That may be obviated by a different sort of chimney, may it not?"—"No doubt it may."

"You are aware that that principle is one of the most important principles which has been introduced into the working by steam?"—"I am quite aware, that on the Liverpool and Manchester rail-way that is the principle they have adopted with some success. We have produced the same effect by another, and I think better means."

"Will you state by what means you produce that effect?"—"Instead of blowing our waste steam into the chimney, in order to produce a draught, we have a fan or blowing-machine, which is driven by the engines when in operation, and this gives us intensity of heat in the furnace. The waste steam from our engines goes into a double casing round the furnace; we admit a small portion underneath the fire-bars of the grate, and the remainder is allowed to expand itself into the double casing, after which it comes over the top of the fire, and escapes in the form of invisible vapour."

"Then in fact you arrive at the same result, but with this difference, that you increase the draught of the fire by using a certain quantity of the power of your engine, whilst those who introduce the steam into the chimney increase the draught by a power which you throw away?"—"We have tried it in both ways, but we find this the most advantageous, because in those carriages in which the steam is driven into the chimney to produce a draught, the aperture is so much diminished, in order to produce velocity of current and corresponding increase of draught, that the waste steam is choked in escaping from the engines, and produces a greater loss of power than by working the fan."

"What distance did you travel on that ascent?"—"The hill is about 200 yards long."

"In what space can you turn on a road?"—"We have frequently turned entirely round on the London-road leading from Southampton, in the space in which a post-chaise can turn, or rather less."

"Supposing you were travelling at the rate of ten miles an hour on a level road, in what number of feet do you suppose you should be able to stop your carriage entirely?"—"We should be able to stop the vehicle in the space of twelve feet; I have ascertained this from experiment: when we were descending Staines-bridge, which is very steep, one of the crowd fell down in front of the vehicle, very near the vehicle; we immediately reversed the action of the engines, and the man escaped without any injury."

"When you state that you can stop in twelve feet, is that by reversing the action of the engines?"—"No; by merely shutting off the communication between the boiler and the engines."

"But supposing you were in such situation that it would be requisite to stop in a much shorter distance, could you do it instantaneously by reversing the engine?"—"We could certainly stop in the space of three feet by reversing the engines; but it would not be prudent to do so in less, as it might endanger the lives of the persons on the vehicle by their being pitched or thrown forward."

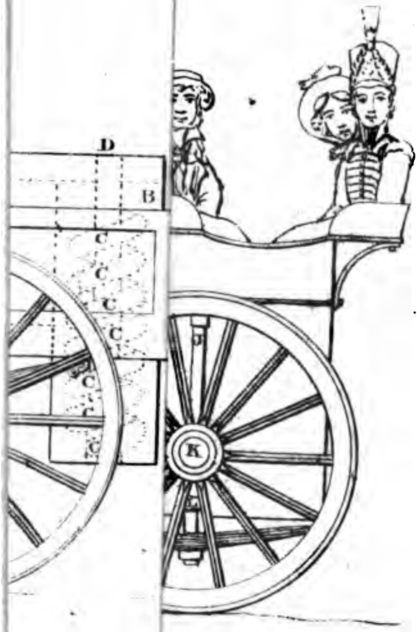
"What is the horse-power of your engine, according to the common modes of calculation by engineers?"—"About twenty horse-power."

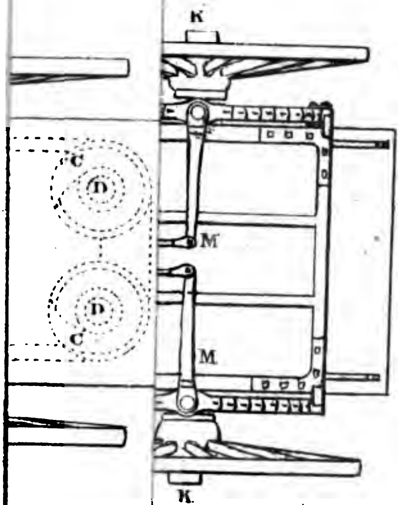
"What do you think ought to be the breadth of the tire of a steam-carriage calculated to convey sixteen passengers?"—"Three inches."

"What do you think should be the breadth of the tire of a carriage calculated to convey twenty-four passengers?"—"Not less than four inches, probably it may be found advantageous to make the tire wider than that in practice; I think it probably will."

Mr. Gibbs, in the early part of the year 1831, obtained a patent for a boiler with a descending flue, for the purpose of economising fuel. He also has built a steam-carriage, and adapted his new boiler to it. The boiler is 5½ feet from the top to the bottom, and 1½ feet diameter. It is placed vertically at the hinder part of the carriage. The fire is made within a foot and a half of the top of the boiler, and the flue descends spirally through the water below the fire-place; and is at its extreme end as cool as 100°. The fire is urged by a blast. With this he has in his experiments required 80 gallons of water per hour, and only used 80 pounds of good coke.

It has been shown that from all high-pressure puffing steam-engines there is a loss of heat. The waste steam blown away, is so much heat driven off unapplied; and the source of power being heat, such is consequently a great loss of power. In stationary engines, part of this loss is easily avoided by condensing the steam with cold water, and returning it in the state of water to the boiler. The water thus pumped back being partially heated, does not require as much fuel to form it into steam as cold water requires. The condensing water would add, however, a weight to the carriage which would be more expensive than useful. A means was tried with considerable success by Mr. D. Gordon, for his locomotive carriage above described. At the side of the carriage-body he attached a condenser, which was kept cool by evaporation. The waste steam from the engine was blown into a horizontal tin tube, 5½ feet long, and 5 or 6 inches diameter, from which 40 vertical pipes of half-inch diane has bee Patentee. Pl. 13





meter proceeded to another horizontal tin tube, of dimensions the same as the large tube. Amongst the vertical pipes, and closely in contact with them, several folds of hair-cloth were entwined. Upon this hair-cloth, water was allowed to drop at various places, which, evaporating by the breeze, condensed the steam, and the hot water was returned to the boiler. A breeze sufficient for the evaporation is almost always to be had in locomotive carriages, which create a breeze for themselves.

Mr. Trevethick described to the Committee of the House of Commons, a plan he had in view for constructing a safe boiler and a good condenser. (See Report, p. 66.)

"I have made an entire new engine, both in principle and arrangements; the fire-place, boiler, and condenser, are formed of six wrought-iron tubes, standing perpendicular on their ends, encircled the one within the other for the purpose of safety, and to occupy little room, also for keeping the boiler to one constant gauge, with fine distilled water, permanently working without loss, by condensing the steam and never suffering it to escape out of the engine, but returning it from the condenser back again into the boiler every stroke of the engine by a force-pump, and where an engine is perfectly tight it would work for ever without a replenish of water; but to supply leaks a small evaporating apparatus is used for supplying the deficiency with distilled water, which effectually prevents any fluctuation in the height of water in the boiler or collecting sediment, and an impossibility of ever getting the boiler red hot, there being no space for the water to fly to out of the boiler but into the condenser; and this is so small, that if by any means the force-pump did not return the water regularly from the condenser to the boiler, the space in the condenser, by taking one inch in depth of water out of the boiler, would fill and glut the condenser so, that the engine would stand still, and, as the water cannot diminish, it does not require a large quantity of water, or water space in the boiler, so necessary in other engines, to guard against fluctuation in the feed, and prevent the boiler becoming red hot. The boiler being considerably less, the strength and room will be increased, and, never getting hot, the engine might be worked with much higher steam. My engine to be one hundred horse-power, to raise sufficient steam, the fire-tube must be three feet diameter, which would give the boiler a diameter of three feet eight inches, and that a half-inch thick, according to the theory of the strength of iron, would sustain a pressure of 1,736 pounds to the inch, which is four times as great as the gas-holders are charged with, and thirty-two times the pressure that the high-pressure engines work with at present, which is still farther proof that the explosions have been solely occasioned by the boilers being under water gauge, and heated red hot. If after boilers have been forced on their trial by a cold-water pressure, to stand ten times the pressure that they are to be worked at, and a boiler should happen to explode, the shock would be first received by the next surrounding tube, and so on for six successive surrounding tubes; each space between the tubes would admit the steam to escape gently up the chimney without harm, and the outside tube that encircles the whole might be made of three-quarters of an inch thick, so that it would put injury from explosion beyond possibility."

Several schemes have been tried for locomotion, by means of men's power working-wheels, treadles, levers, or oars. But from experience in the velocipede, proposed for homo-locomotion, and extensively used as an instrument of exercise and amusement thirteen years ago, the most admirable contrivance of the kind ever exhibited, it was found that a man, "sound in wind and limb," could walk or run five miles on his feet with greatly less labour than he could wheel himself the same distance on a velocipede. The inexplicable vital principle bestowed by the omnipotent God upon his creatures, cannot be superseded by man's utmost knowledge in mechanical science: and experienced mechanicians have for long abandoned the attempt.

The boilers described as having stood the test of actual and *continued* use, for locomotion, are the old high-pressure boiler of Mr. Trevethick, with its modifications; the *tubular boiler* of Mr. Gurney; the *laminated boiler* of Mr. Hancock; and the boiler, with *tubular flues*, of Messrs. Stevenson and Co. And in proposing an extensive adoption of elemental power for locomotive purposes, it may be well to give some comparison of their safety. In Mr. Trevethick's old boiler no attempt is made to introduce a tubular construction for the purposes of safety; neither does there appear any in Messrs. Stevenson and Co.'s, for the tubular flues of the latter are resorted to, in order to obtain an increase of heating surface in a small space.

The duration of boilers is a matter of great moment, and in this particular Stevenson and Co.'s are less valuable than Gurney's. The chemical deposit called fur, is with difficulty cleaned out, and if not thoroughly cleaned out, the heat from the fireplace and flues is not transmitted to the water with sufficient rapidity, and hence a deterioration of the boiler. A remarkable instance of one boiler lasting longer than another was mentioned by Mr. Thorold, to the institution of engineers. He had under his eye two boilers constructed at the same time. The cross section of one was a circle, and the cross section of the other was of a crescent-shape, with the horns downward. In the cavities of the horns, or legs of the latter, which rested on the brick-work of the furnace, the fur and mud collected so readily that the water could not carry off the heat from the fire with sufficient rapidity. These legs of the crescent-shaped boiler consequently became red hot, and in *three weeks* the boiler was useless. Whilst the boiler first-mentioned, whose cross section was completely circular, had worked for *nine years and a half*, without repair, and the engine during that time was uninterrupted in its working except for the purpose of cleaning. It is an error to suppose that the deposit can be blown off with the water like as much muddy water: so much of it as is composed of mud may be god rid of, by blowing off, but the chemical deposit of fur requires to be chipped off. The owners of tubular boilers have got rid of this fur partially, in consequence of another evil; the boiler, when *red hot*, casts scales of fur, which are blown out sometimes with the mud. But such a remedy is as bad as the disease. It will be seen that Mr. Gurney, by removing the plugs at the corners of his tubes, can chip and rake out the fur. The plugs on the tubes, and the flaunches on the larger chambers, giving the most perfect facility for so doing.

The perfect safety of Mr. Hancock's and of Mr. Gurney's boilers will be seen at once, by reference to Plates X and XI.

Upon the comparative merits of these boilers, Mr. Farey says, (Report, p. 41) :—

"There have been, for several years past, a number of locomotive-engines in constant use on rail-ways, all of them having large high-pressure boilers, very much more dangerous than Mr. Gurney's or Mr. Hancock's, whether we consider the probability of explosion, or the consequences likely to follow an explosion, because being of large diameters they are less capable of sustaining the internal pressure of the steam, and also they contain a large stock of confined steam and hot water. The instances of explosion among those locomotive-engines have been very rare indeed."

"If Mr. Hancock's boiler were to explode, it is understood that there would be no danger at all?"—"It is very difficult to foresee that; at the same time the risk of explosion in Mr. Hancock's boiler is certainly very much less than in the locomotive boilers, which are in constant use on a large scale on rail-ways, and where we have proof that the extent of the danger is very small."

"Do you think his boiler might explode without the passengers knowing any thing about it?"—"The metal plates of which the boiler is composed will burn through by the continuance of the action of the fire, and may crack or open so as to let the steam or water out of the boiler and disable the coach from proceeding, but that is hardly to be called an explosion; no one would be hurt; the crack which lets out the hot water is sure to throw it into the fire in that case, and not on the passengers."

"You consider the danger to passengers by the chance of bursting of a boiler as not equivalent to the danger of horses running away?"—"It is not equivalent in my opinion; the probability of a coach being overturned by the horses is far greater than that of a boiler bursting, and when either accident does occur, the probable extent of mischief from an overturn in which all the passengers must participate, is much greater than could be expected from the bursting of a boiler, which must always be kept at a considerable distance from the passengers on account of the heat."

"Supposing either Mr. Hancock's or Mr. Gurney's boiler were to burst; in the one case the boiler being in a separate carriage, and in the other, the boiler being at a considerable distance behind the passengers, what danger do you think could arise to the passengers from the bursting of the boiler?"—"There is very little difference between the two cases; the separate carriage obviates any apprehension that passengers could entertain from the danger of explosion, and will therefore be preferred by most passengers, but for myself I do not rate that risk so high as to be induced to encounter the complexity of the two carriages, and to forego some of that new security which steam power offers by its controllability in descending hills and turning corners, compared with horses; and in which circumstance, as I have before stated, I think the plan of one carriage is much to be preferred, and probably the other objections of heat and noise and dust may be overcome by some new means, which have not yet been shown."

"Is not the danger attendant on the bursting the boiler greatly diminished by the subdivision of its internal capacity into tubes or small and flattened chambers?"—"Unquestionably, until the danger of explosion has become exceedingly small; but the great difficulty of boilers for steam-coaches is, that the liability to burn through the plates has been increased by that expedient for ensuring safety; and the progress of the invention has been impeded between those two difficulties in a greater degree than from any other circumstance. It was a desideratum for a long time to contrive a boiler, which being made of such thin metal, as would not render it too heavy, should have sufficient strength to retain high-pressure steam without danger of bursting; also that it should expose a sufficient external surface of metal to the fire and flame, and of internal surface to the contained water, to enable the required quantity of steam to be produced from such a small body of water as could be carried on account of the weight; both these conditions were fulfilled by subdividing the contained water into small tubes or into flat chambers, which expose a great surface in proportion to their internal capacity, and admit of being made strong with thin metal; but there is also another condition which is rather incompatible with the two former, viz. that there shall be such a very free communication between the interior capacities of all the tubes or narrow spaces, as will combine them all into one capacity, and permit the contained water to run from one to another, and also permit the steam, which is generated in innumerable small bubbles within the narrow spaces, to get freely away from them, to go to the engines without accumulating and collecting into such large bubbles as would occupy the spaces and displace or drive out the water before them; for if that effect takes place it produces three great evils; the water boils over into the engines along with the steam and is wasted, and the thin metal which remains exposed at the outside to the fire becomes burning hot in an instant, after the water is so driven away from the internal surface, and the further production of steam is suspended, so long as the water continues absent. If such displacement of the water takes place frequently, and in many of the narrow spaces at once, the boiler will not produce its proper quantity of steam, and the thin metal will soon be destroyed by the fire and burned through."

"Have you seen Mr. Hancock's boiler?"—"Yes; I have had many trials of it; and I am well acquainted with Mr. Gurney's: the former uses flat chambers of thin iron plate standing edgeways upwards over the fire in parallel vertical planes; the latter uses small tubes (such as gun-barrels are made of) to contain the water, the fire being applied on the outsides of the tubes. In Mr. Gurney's boiler I think the subdivision of the water into small spaces is carried too far, because the steam cannot get freely away out of such small tubes as he uses (and they are also of great length) without displacing much of water which ought always to be contained within them. By an ingenious arrangement of connecting pipes and vessels which he called separators, he collects all the water which is so displaced along with the steam, and returns it again into the lower ends of the same tubes, and thus avoids the evil of water boiling over into the engines; but that makes only a partial remedy for the diminished production of steam, which is attendant on the absence of the water from the heated tubes, and the still greater mischief of burning and destroying the metal. Hence the evil of burning out the tubes is very great. Also his separators hold a considerable weight of water, from which no steam is generated; and they require to be heavy in metal, to render them quite safe and strong. Mr. Hancock has taken the middle course in subdividing the water in his boiler, having all that can be required for safety, and the weight I believe, on the whole, to be less than that of any other boiler which will produce the same power of steam; for, owing to the freedom with which the steam can get away in bubbles from the water without carrying water with it, the surface of the heated metal is never left without water. Hence a greater effect of boiling is attained from a given surface of metal and body of contained water, and that with a much greater durability of the metal plates, than I think will ever be obtained with small tubes."

"Do you think there is a danger of such an explosion as could do injury from the mode in which Mr. Hancock's boilers are constructed?"—"That danger I hold to be very slight; the metal of Mr. Hancock's chambers will burn through in time, the same as that of Mr. Gurney's tubes will do, but not so soon; I think, taking the thickness of metal to be the same in both cases, no injury will be done by such burning through. The flat chambers in Mr. Hancock's boiler are very judiciously combined, and are secured against bursting by causing the pressure which tends to burst each one open to be counteracted by the corresponding pressure of the neighbouring chamber; and the outside chambers are secured by six bolts of prodigious strength, which pass through all the chambers, and unite them all together so firmly that I see no probability of an explosion. Mr. Gurney's vessels, called Separators, are secured by hoops round them, and being of a small size, may be made very safe. Hence I think the two boilers may be put on a par as to their security; but there is a decided preference in my opinion of Mr. Hancock's form of subdividing the water and steam compartments, which I believe is carried too far in Mr. Gurney's tubes, whereby the water, included within the several tubes, cannot make way to allow the bubbles of steam to pass by it. This is owing to the great length and the small bore of the tubes; and they are so isolated one from another, that the water within them is not able to act as a common stock of water, or to keep all the interior surfaces of the metal tubes thoroughly supplied with water: thence there is a deficient production of steam and an unnecessary destruction of metal."

"Are you aware that, in Mr. Hancock's carriage, the waste steam which is discharged from the engines after having performed its office is thrown into the fire-place, and makes its escape upwards along with the flame, smoke and heated air, and gas, which ascend from the fire to act on the boiler?"—"That is the way in which he gets rid of the waste steam which the engines discharge, and I understand that he thereby avoids the puffing noise and appearance of steam which is common with high-pressure engines. Mr. Hancock blows the fire with a current of air, produced by a similar fanner, which is turned rapidly round by the engines, and therefore he requires no tall chimney to produce a draft. Mr. Gurney formerly used a singular fanner to blow the fire, and also a chimney of some height; but I understand he has lately laid it aside, and adopted the plan of carrying the waste steam which has passed through the engines into the bottom of the upright chimney, and there discharging that steam through a contracted orifice in a vertical jet, which, by rising upwards with great velocity in the centre of the chimney tube, gives a vast increase to the draft of heated air and smoke in the chimney tube, without any great height being necessary; and this plan occasions a most active current of fresh air to pass up through the fire, and urge the combustion. This is a most important improvement in locomotive engines, which has been introduced by Mr. Stephenson into his engines on the Liverpool and Manchester Rail-way, and being there combined with an improved boiler, it has been one of the great causes of the brilliant success of that undertaking. I believe the same plan will be indispensable to the complete success of steam-carriages; for chimneys cannot be used high enough to obtain a draft, and blowing the fire is a very troublesome affair. I fear Mr. Stephenson's plan would occasion more noise than is allowable on common roads; but that may perhaps be avoided or diminished by some new expedient." * * * * * *

"The waste steam was very commonly discharged into the bottom of the chimney, in Trevethick's high-pressure engines, many years ago, in order to mix with the smoke ascending in the chimney, and thus get rid of the waste steam; it improved the draft in that way, by rendering the smoke more buoyant, but only in a slight degree; but the waste steam was not discharged through a contracted orifice to give it velocity, nor was it directed upwards as is now done by Mr. Stephenson; and that vertical jet of steam in the centre of the chimney gives such an intensity of draft through the fire as was never procured before, and with the further advantage that the rapidity of draft so produced increases whenever the engines work faster, and discharge more steam, just in proportion as the demand for fire and steam increases by that working faster."

"Is there any noise occasioned in that way?"—"Yes; but the sound is directed upwards by the chimney, and is not much heard in the locomotive engines on the rail-way when they are in the open air, but when they pass under the bridges, the sound is reverberated down again by the arch, and then it sounds very loud. The noise is of no great consequence there, and no particular pains have been taken to avoid it. The metal pipe of the chimney has something of the effect of an organ-pipe or trumpet, but it is probable the sound might be deadened."

"Will the burning out of the plates of Mr. Hancock's boiler, that you spoke of, be attended with risk of explosion of the whole boiler, or only of the smaller divisions of the boiler?"—"It will be attended with no violence which could be called an explosion, nor with any danger whatever, but only with the inconvenience of disabling the carriage until the ruptured chamber is replaced by another. The rupture or crack of the metal-plate at the burned place would let out the water and steam very gradually into the fire, and probably extinguish it. All steam-boilers burn out in that manner sooner or later."

This opinion of the comparative value given by an engineer, of acknowledged talent and great practice, particularly in steam-power, must however be a little qualified by the fact of his not having minutely inspected Mr. Gurney's boiler for a very long period, perhaps three years.

The report of Mr. Crawshay, of Cyfarthfa iron-works, to Sir Charles Dance, gives a view of Mr. Gurney's boiler and locomotive engine on the rail-road at Hirwain, which confirms me more strongly in the belief that his boiler is the best yet constructed for locomotive purposes. My opinion was, however, previously formed, in consequence of long experience with four of these boilers, in three distinct pieces of machinery under my management. In one of these works I had one of his boilers constantly under my eye for two years. Our difficulties lay in the length of the pipes, which were apt to choke up with fur. Since that time various improvements have been made, and the result is exhibited in the constant and steady work of the locomotive-carriages at Gloucester, and the said recent report of Mr. Crawshay, viz.:

"*Cyfarthfa Iron Works*, 23*d Feb.* 1832.

"The favourable opinion entertained by my engineer and myself of the tubular boiler (Mr. Gurney's), over every other we have yet seen, not only remains unshaken, but is strengthened and confirmed by eighteen months constant use, and observation of it on our own road; and also by all we can collect from other testimony, of what is doing elsewhere in this neighbourhood with boilers of other description. The ease and economy of first construction; the facility of repair when required; the extreme lightness; the great capacity for raising steam; and the perfect freedom from danger of the tubular boiler, all render it, in our opinions, pre-eminently adapted to locomotive-engines; and I hope in the course of a few months to apply it to engines and carriages suited to rail-roads and heavy work so successfully, as to render the advantage of steam-power over that of horses still greater than it now is. As, however, facts of past performances of any kind are more satisfactory than anticipations of the future, I beg to state to you, that in the past twelve months, between the 1st day of January, 1831, and the 1st day of January, 1832, the locomotive-engine which I bought of Mr. Gurney, weighing only thirty-five hundred weight, including every thing whatever belonging to it, with water and fuel in a working state, conveyed 42,300 tons of coal, iron-stone, and iron, exclusive of the carriages on which they were drawn, the distance of two and a half miles upon our rail-road at Hirwain, in journeys of from twenty to thirty tons, as suited our convenience; during which time, the entire consumption of coal was 299 tons, which at 3*s.* per ton amounts to 44*l.* 17*s.* The wages of the engineer 52*l.*, and those of the boy 15*l.* 12*s.*, together, exclusive of the trifling repair of the engine, and the oil and other little matters required for its use, 112*l.* 9*s.*, or less than one farthing per ton per mile, for the goods conveyed; and I must not omit to observe to you, that had there been nearly double the work to do on this road, the engine would have done it with little or no increased expense, as she was invariably working idle for the purpose of keeping the boiler full, about one-half of her time.

"You are sufficiently acquainted with the experience of horse-power, to render any comparison on my part unnecessary; but from the observation I have been enabled to make, in contrasting horse-power with that of steam on the same road, I should certainly consider that the average of horse-power, compared with that of steam, under the most improved application, is in point of expense as twenty or even thirty to one; independently of many other valuable considerations in favour of that of steam, known only to those who have large and expensive stable-establishments, in which valuable horses, after sustaining hard work all day, are exposed to the negligence, roguery, and ignorance of hawliers, horsekeepers, and farriers; while the engine, having completed her day's work, may be left without anxiety as to the attention of any of these notoriously troublesome persons until again called into use.

"I consider that the unprecedented depression of the iron trade, and the late disturbances in South Wales, have much impeded the further introduction, use, and improvement, of locomotive-engines in this part of the country; and it is a matter much to be regretted, that more talent, competition, and energy, are not at this moment excited every where in the furtherance of so great a national advantage, as the substitution of the cheaper power of steam, *wherever practicable*, for that of horses.

(Signed) "WILLIAM CRAWSHAY."

CHAPTER IV.

THE ROADS UPON WHICH STEAM-CARRIAGES MAY BE MADE TO TRAVEL.

We introduce this chapter with an anecdote which, we doubt not, is familiar to many of our readers, and which, without wishing to appear ill-natured, is so descriptive of the conduct of several scientific men with whom steam-carriage projectors have to deal, so apt to our purpose, that we cannot pass it by. Once upon a time—we like this old school-boy-tale-method of opening a subject; there is something racy in the very smack of it. Once upon a time, a laughter-loving monarch proposed to the philosophers, projectors, wise men, and civil engineers of his court, with a gravity becoming the importance and intricacy of the matter, the following problem:—"Take a globe of any given dimensions, fill it with water, and then put a gold fish into it, how does it come to pass, that by doing so you neither cause the water to overflow, nor increase the specific gravity of the globe and its contents?" Here was a puzzler to be sure! The whole conclave were thrown upon their beam-ends, and to resolve the difficulty became a subject of almost national concern. Then there was such a laying of heads together! and learned descantings, philosophic disputations, and theories, were broached in support of it—all of them most weighty, ingenious, and deep. Each party sported

——————— "Speculations wild,
And visionary theories absurd;
Prodigiously, deliriously absurd,
Compared with which, the most erroneous flight
That poet ever took when warm with wine,
Was moderate conjecturing."

Each opposing stoutly the opinion of the other. At length an individual of the number, more sceptical and less credulous than his associates, suggested the propriety of putting the matter to the proof. The bubble burst, and the fact, encumbered as it was with a load of theoretical supports, showed the gravity to be + the gold fish. These philosophers were nonplussed, and the king had his laugh; but the result should have proved a warning to all sapient fraternities to the end of time. It finds, however, a curious and ludicrous application in the present day. The *non-possibility of steam-carriages ascending a hill* is the *fish in the bottle* with many of the wise men, philosophers, and mechanicians. They have met often, and discussed long, and talked learnedly, and descanted philosophically, and endeavoured to make out the *non-possibility* of it by all manner of arguments and means. But the fact outlives their reasonings, and the possibility of the thing proved *experimentally*, rests upon a plain practically demonstrated basis.

But to return to the evidence before the Committee we find that Mr. Farey, who is by no means solitary in his opinion, when asked by the Committee, if he had ever seen a steam-carriage going down hill, says, "Yes." (Report, p. 50.)

> "But I do not contemplate the descent of steam-coaches down very steep hills, for that supposes their getting up such hills, which is not likely to be accomplished soon, and the present coaches seem to me to be only fit for our most improved lines of roads, where all very steep hills have been reduced to moderate slopes."
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> "Have you turned your attention particularly to the subject of going up steep hills, and what ascent do you think can be surmounted?"—"In forming my opinion of the probability that steam-carriages will be brought to bear, I could not overlook the circumstance that they would have to go up and down hills; but most of our great lines of roads are now so improved, that what were formerly called steep hills, are not very numerous or frequent; but wherever they do occur, I propose to give the steam-coach the assistance of a pair of post-horses in aid of its own power. In going down hill, steam-coaches are very safe, because the whole power can be effectually exerted to retard or resist the turning of the wheels."
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> "Mr. Gurney's steam-coach has gone up Highgate Hill without horses?"—"Yes, but I understand that it was broken to pieces in coming down again[1]."

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[1] This breakage in coming *down* hill has certainly nothing to do with going *up* hill. It may be seen from the few lines previous, that Mr. F. says, "In going down hill steam-coaches are very safe." But to put this breakage in

"Do you think there is any danger in going down a hill in a steam-carriage?"—"Much less than in a common stage-coach; for by backing the engines, so that their power is brought to act in opposition to the turning round of the wheels, and with the assistance of drags, or brakes, rub on the rims of the wheels, and aid in retarding their motion by friction, steam-coaches will safely get down all moderate hills, such as are met with on our best lines of turnpike-roads, say between London and Holyhead; and with machinery such as Mr. Hancock is now making, if it is suitably proportioned, I expect a steam-coach would not require assistance to get up hill at more than five or six places between London and Holyhead."

"Stanmore and Highgate Hill you call moderate hills?"—"Not the old Highgate Hill; but the Archway is a very fair road, on which a steam-coach should not feel the least difficulty. I do not call those moderate hills which are common on the roads in many parts of Devonshire and Cornwall; it will be a long time before steam-coaches will be able to travel there; and the goodness of the roads is to be considered as well as the slope. No steam-coach that I have seen possesses that strength and weight of machinery which, being on the present construction, will enable it to get up even a moderate hill without risk of breaking; for though it may climb up the hill by accumulating the strength of the steam, the parts have not been made strong enough to resist the strain to which they are then subjected, if they were frequently used; and if the work were made, on the present plan, strong enough to endure the extra strain of getting up a steep hill with safety, there would be too much weight of machinery for travelling on the ordinary road."

"Can they ascend a hill so steep as one in eighteen?"—"That[1] I think is too much for them, without the aid of horses, unless the surface of the road were of the very best quality; but such hills are usually bad roads."

"Are they competent to ascend such a hill as St. James's Street?"—"I have not a very particular recollection of the slope of that hill, but I believe it is paved, and I think that it would be about their maximum; for a great deal would depend upon the surface of the road: they would go up all the length of Regent Street, which is, I expect, almost as steep as St. James's, but it is a

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its proper light, I may state, that this occurred five years ago! shortly after Mr. Gurney had proved that steam-carriages could go up hill. On that occasion, the carriage was coming down Highgate Hill "without any drag to it; it became difficultly manageable, ran against a stone, and was upset"—*not "broken to pieces."*

[1] This will not be much to surmount when Mr. Crawshay's letter, p. 71, has been read, wherein he says, an ascent of one in eight was travelled up by Gurney's engine. I have been propelled up Stanmore (old) Hill, and many others, and know that they were surmounted with ease. Stanmore Hill is not a short hill, but a *very long hill,* rising two inches and a half in the yard, and in some places three inches in the yard, or one in twelve; and although this is not the steepest ascent I have travelled by steam, the length of the hill is such as to render the fact more valuable.

better surface; and I think they should go up any good road not exceeding a rise of one in thirty; and if more inclined, or if the road is bad, they should be allowed one or two horses."

Mr. John M'Neil, engineer, Daventry, whose sound evidence will be read with much satisfaction, gives a very favourable view of the power of steam-carriages to go up hill. (Report, p. 102 and 103.)

"Do you think it would be necessary to make any alteration in the form of the present line of turnpike-road for the facility of working by steam?"—"I do not think it would be absolutely necessary; it would, however, be of great benefit to the country, and every person in it, if the hills on the present lines of road were more reduced, and the surface strengthened; no road should have a greater ascent than one in thirty, or one in thirty-five."

"But have you any doubt whatever that steam-carriages can be brought into practical use, with great benefit to the public, even on the present lines of turnpike-roads?"—"I am quite convinced they can."

This gentleman's knowledge of roads, and the action of wheels upon them, would have been quite sufficient to convince us that such must be the case, even if we had not the most substantial proof that it is so.

The road trustees, we have shown in the last chapter, opposed steam-carriages, fearing that the roads might be injured. Upon this point the Committee of the House of Commons were most particular in their inquiries.

Mr. Gurney examined. (Report, p. 23.)

"Are the wheels you ordinarily travel with four inches wide on the tire?"—"From three and a half to four inches."

"Have you any information to give to the Committee in relation to the relative wear of the tire of wheels and the shoes of horses?"—"That is a new horse-shoe [*producing one*], and this is a shoe, of the same size, worn on the streets of London nine days; the shoe has lost about 18 ounces."

"Have you any means of ascertaining how many hours a day it had been out?"—"The horse ran in a cab; it was out a certain number of hours—I think, three or four hours each day: the smith was taking off the shoe which had been worn, and putting on the other, when I asked him to let me have them. The difference between the wear and tear of tires and horse-shoes on the roads in the neighbourhood of London, is in the proportion of about three-fourths on the shoes, and one-fourth on the tires; but in London, over the streets, about seven-eighths and one-eighth. I would observe, that on rail-roads, where horses draw the carriages, the expense of keeping the horse-roads is so great, that the proprietors frequently go to a great expense to pave them. From Cheltenham to Gloucester, for instance, and in many other parts of England, this is the case. I would also call the attention of the committee to some parts of London, where the horses and the wheels continue to pass over the same ground respectively, as in Wych Street; and I would submit the importance of the committee referring to the expense of keeping the towing-paths of canals in repair, where only horses, and comparatively few, travel over them. At this moment, those are the only means enabling me to speak to the relative wear and tear."

"Have you used your carriages on pavements?"—"Yes; never to run continually on pavement, but to run in and out of towns."

"Do they run easier on pavements than on ordinary roads?"—"Yes; they only take about a quarter the power on a pitched pavement; that is, a quarter of the power they would over a gravelled road."

"In the progress of this improvement, do you anticipate that it will be necessary to adapt some portion of the turnpike-roads to carriages of this description, or do you think they can be put into operation on the turnpike-roads as they are now existing?"—"I think they can be put into operation on the turnpike-roads as they are now existing; I have no doubt at all about it."

"You do not anticipate the necessity of paved roads being made for the purposes of those carriages?"—"As far as economy goes, in the expense of power, it may be desirable; but for the practical application of the steam, it is not necessary."

"Can any proportion be drawn between the friction occasioned by the horses' feet and the tire of the wheel?"—"I do not see how it is possible to do so, unless you take the loss or abrasion of the two metals respectively, in a given quantity of work or miles travelled over."

"Have you any practical experience in the repair of turnpike-roads?"—"I have had my attention turned to it, connected only with this subject; I have seen the great expense of keeping towing-paths and horse-paths in repair; and I have seen the great expense of keeping the streets in repair, where horses alone travel; and I have seen the great wear and tear of iron shoes, when compared with the wheels of carriages."

"Have you any plan to submit for fixing the tolls on steam-carriages?"—"The plan I should propose would be, if I may be allowed the term, that an iron horse, of the same weight as one of flesh and bones, should pay the same toll; and taking one horse to weigh 10 cwt., that for every 10 cwt. the steam-carriage weighs, it should pay the same toll as one horse pays; although I do not admit that the same weight carried on four wheels will do as much mischief as on four hoofs. If we take the Turnpike Acts, and look at the comparative rate of tolls charged when a horse is drawing and when he is not drawing, I shall be, I conceive, borne out in my position."

"Can you point to any clauses in private bills which press more than you conceive they should on steam-carriages?"—"There is one, the Liverpool and Prescot Road-Bill, this session, charging a toll per horse-power, which it is difficult to determine. My objection to that is, that if the horse-power is taken as the nominal engine horse-power, a steam-coach would have to pay 2*l.* 8*s.* where a stage-coach pays only 4*s.* a toll. The next is the Bathgate, near Edinburgh road, where the tolls are on weight, and an engine of three tons (about the usual weight of a loaded four-horse stage-coach) would have to pay 1*l.* 7*s.* 1*d.*, when four horses would have to pay 5*s.* The next is the Ashburn and Totness Road-Bill, where 2*l.* would be charged on the steam-carriage and the carriage attached, being 5*s.* on each wheel; four horses at the same time would have to pay 3*s.* The next is the Teignmouth and Dawlish roads; they are in the proportion of 2*s.* and 12*s.*"

"What is the most favourable instance to steam-carriages?"—"The Metropolis roads, near London, charge 1*s.* for four horses, and 2s. for the steam-carriage and the one drawn. I complain of that because it limits me to a particular kind of carriage: I am building one which will not weigh more than 5 cwt., and carry only two or three persons, and it would be excessive to have to pay 2*s*; there is no reduction if it is no bigger than a wheelbarrow; being propelled by machinery, it will be charged double."

"How many private bills have been introduced this session, in which steam-carriages have been specially taxed?"—"I have fifty-four, which I now produce; I understand there are others."

"Have any of them passed into a law?"—"Yes, some of them have."

"In your opinion, what proportion of the tolls should horses and carriages be chargeable with?"—"Taking the average of the amount of tolls throughout the country, it will be found that where a horse pays a penny not drawing, he pays about three-pence when he is drawing; in that case, the toll upon the coach is nominally put upon the horse (it says, so many horses drawing). Four horses drawing will be a shilling; four horses passing through, not drawing, will be fourpence: in some cases it is three half-pence a horse when not drawing, and sixpence when drawing; but in general the proportions appear to be, three-eighths the toll placed upon the horse, and five-eighths upon the carriage; three half-pence a horse not drawing, and sixpence drawing, gives three-fourths; but the mean is about three-eighths and five-eighths; so that the toll is virtually about five-eighths on the carriage, and three-eighths on the horse. I have previously stated that I have had horses weighed, and found the average about 10 cwt. each horse; therefore, if a steam-engine weighs 10 cwt., it should pay only as one horse when it passes through not drawing, and as one horse drawing when it has any thing attached to it. A 10 cwt. steam-engine cannot propel more than one horse can draw; therefore the weight drawn cannot exceed a certain quantity. If the weight of the engine exceeds 10 cwt., and not 20, it should pay as two horses; if it exceeds 20, and not 30, it should pay as three horses; if 30 cwt., and not exceeding 40, it should pay as four horses; and so on."

"Practically, horses drawing frequently draw a weight of 30 cwt.?"—"Yes, sometimes; but 15 cwt. a horse is the usual weight. I have always felt a great anxiety that the weight of the steam-engine should not injure the road, and I have felt desirous of not introducing it until it was reduced; and I now cheerfully admit, that if the weight of the locomotive exceeded 60 cwt., which is the weight of the present loaded stage-coaches, with the passengers and their luggage, there should be a very heavy toll put on them. I would also propose, that if my wheels are wider than four inches, the tolls should be less; if they are six inches, then they should be still less; but taking the principle of 10 cwt. of iron and copper to do the work of one horse, and that it should pay the same tolls, and that no weight of steam-carriage should be admitted above 60 cwt. on the road, I certainly should myself be content; and as I cannot for a moment imagine that the 10 cwt. running on four wheels can do so much harm as 10 cwt. carried on four feet, the interests of turnpike trusts would be fairly preserved by such a scale of tolls."

"What is the amount of toll charged between Gloucester and Cheltenham?"—"Five shillings and sixpence."

"What would be charged on a four-horse coach?"—"Two shillings and eightpence."

Mr. Farey examined. (Report, p. 45.)

"Apprehensions have been felt by trustees and surveyors of roads, that steam-carriages are more injurious to the roads than carriages of equal weights drawn by horses; what is your opinion upon that point?"—"I should not apprehend that the present coaches are injurious in a greater degree than other carriages of equal weights; and when steam-coaches are really brought to bear, I think they will be much less so than any carriage at present in use, taking horses and the carriage they draw against engines and the carriage they impel, at weight for weight. All my observation upon steam-carriages has led me to believe, that they do no particular harm to the road; I could never perceive any peculiar marks that they left in their tracks; and an examination of the iron tire on the edges of the wheels of Mr. Hancock's carriage shows evidently that no slipping takes place on the surface of the road; and that fact is proved to a certainty by other observations on the working of that carriage. It will be a long time before a sufficient number of steam-carriages travel over any road to bring their effect on the materials to the test of experience; but on general principles I have no hesitation whatever in stating my opinion, that they never will answer as long as they do injure the roads any more than the fair wear occasioned by the wheels of other carriages of the same weight: for any injury they might do to the road must be by a slipping of their wheels on the road, which would be a waste of the power of their engines, and hitherto they have had no power to spare; or, if their wheels are too narrow, and they cut deep into the road, the power of the engines will be wasted. If they are to be efficiently advanced, the whole power must be fairly exerted in advancing them forwards along the road, without turning their wheels in vain on the road, or cutting ruts in the road. I am confident that, if the wheels slip at all on the roads, so as to lose motion, or if they penetrate so as to make ruts, those coaches will not answer, and the defects must be remedied, or the coaches must be given up. I do not mean to affirm whether the present steam-coaches which draw other carriages after them do or do not slip on the road, because I have not examined them; but I am of opinion, that for the ultimate successful application of steam-power, the carriages must be so constructed that they will do less injury to the roads than carriages drawn by horses; and whenever steam-coaches become common, I think the roads will be most materially benefited by the change."

"Supposing the total weight of a stage or mail-coach, drawn by four horses at ten miles an hour, to be two tons, and the weight of the four horses to be two tons, what proportion of the wear of a M'Adam road would you expect to be occasioned by the wheels of the coach, supposing them to be the usual breadth of stage-coach wheels, and what would be the wear by the horses' feet?"—"It is impossible to fix an accurate proportion for such a question as that; but I have no doubt but that, weight for weight, horses' feet do far more injury to a road than the wheels of a carriage, and particularly so at quick speeds, because wheels have a rolling action on the materials of the road, tending to consolidate, and the horses' feet have a scraping and digging action, tending to tear up the materials. One test of the wear by horses' feet will be in the wear of towing-paths for canals, and the railway-roads where horses are employed; in either of those cases, the number of horses which pass along is so small, that no turnpike-roads afford any example of comparison, and yet the wear of towing and railway paths is found to be considerable. The rapid wear of horses' shoes is another test."

"It has been stated by a previous witness, that the proportion of the wear of a M'Adam road, under such circumstances, would be about two-thirds by the horses, and one-third by the carriage; should you think that a fair approximation to the truth?"—"I have no means of judging with such precision, but I have no doubt whatever that, in the case above supposed, the wear by the horses' feet would be much greater than the wear by the wheels; for independently of the difference of the action, as before stated, the rapidity of the blows wherewith the horses strike down their feet, in stepping quickly, wears the road, and they keep their feet pressing on the same spot for a sensible time afterwards, which must have a far greater effect on the materials, to wear and loosen them, than the comparatively progressive rolling of the wheels over the road, because the latter remain only an imperceptibly short space of time on the same spot, and have a consolidating action."

"May you take the wear of horses' shoes, in proportion to that of the tire of the wheels, as a fair test of the proportionate wear of the road by each?"—"No, by no means, because the pressure which the wheels exert, and which wears away the tire, is, under certain conditions, very beneficial to the road; whereas the pressure occasioned by the horses' feet is in all cases pernicious. On a gravelled road, which is not yet consolidated, the rolling action which causes the wear of the tire of wheels produces a great improvement of the road, when the treading action, which causes an equal wear of horses' shoes, does nothing but mischief. The harder and more solid the road becomes, the less this may be apparent, because the wear of the road becomes so imperceptible; nevertheless, I think the proportion of less wear by wheels than by horses' shoes will still hold true."

"What is the average width of the tire of the wheels of steam-carriages you have tried?"—"Mr. Hancock's wheels are two inches and three inches broad; in Mr. Gurney's carriage, when he carried the load along with the engines, the wheels were two inches and a half broad; but I understand he has widened them since he has altered his system of drawing a separate carriage, which is to be expected as a necessary consequence of the alteration."

"Do you think the machine would act with less advantage if the wheels were wider?"—"That depends entirely upon the weight resting upon the wheels, and the sort of roads they are to run upon. I think it would be better for those individual carriages to use broader wheels than they had."

"If the tire of Mr. Hancock's were six inches broad, would it be an advantage or a disadvantage?"—"I think six inches would be too wide for that description of carriage; about four inches I should think a suitable width for his wheels. Mr. Hancock's carriage is so arranged, that a greater proportion of the whole weight of the carriage is thrown upon the hinder wheels, to one or both of which the power of the engines is applied, than upon the fore-wheels: that I think is very judicious, because it ensures such an effectual adhesion of the hind-wheels to the road, that no slipping can take place. The breadth of the wheels must be so proportioned to the pressure that they exert on the road, that they will not indent or press in, to leave deep marks behind them. The actual breadth that will be suitable to any given weight will depend upon the hardness of the materials of which the road is made, and roads differ very much in that respect; I think that in all cases the breadth of wheels which will enable the carriage to make the best progress will be that which will do the least injury to the road, for it will be that which will occasion no disturbance of the stones after they have been consolidated, but will only wear away their upper surfaces, and the iron of the tire."

"Is it your opinion that weight for weight, including the weight of horses on one hand, and of engines and an average of the water and fuel on the other, the tolls should be the same on steam-carriages as on horse-drawn carriages?"—"I think that if it were so it would prove a considerable advantage to the roads, because, as I have stated before, I think the roads will be considerably benefited by the change of impelling by steam instead of by horses. I think it will be a great public benefit when steam-coaches come into common use, and hence that it is expedient that a moderate bounty should be offered for the adoption of steam-carriages, by giving them all possible advantage they can have without trenching on the interests of individuals; and if they were allowed to run toll free, and duty free, until a certain number were in use, or during a certain time, it would much accelerate their introduction, because it would diminish the loss that must necessarily be incurred by running them before they are perfected in their construction: small encouragements or discouragements have a considerable effect on new inventions in their infant and imperfect state. Steam-coaches will very well bear all tolls and taxes to which other coaches are subject, when they are able to carry passengers regularly and profitably; but they want encouragement now, instead of difficulties being thrown in their way. As to the right of tolls on turnpike-roads, it should be recollected that turnpike-roads are not property, like canals, but trusts, to be exercised for the benefit of the public; and if it is for the interest of the public that steam-coaches should be brought into use, and if that bringing into use will be accelerated by suspending the tolls on them at first, the trustees of roads ought not to object to such an arrangement: the real amount of tolls they will forego will be an exceedingly small per centage on the income of their tolls; for so long as steam-coaches are losing concerns, they cannot be very numerous."

Mr. Alexander Godon, engineer, examined. (Report, p. 74.)

"Have you been engaged in running stage-coaches?"—"I was engaged in running a stage-coach with horses four years ago, and since this committee commenced their examination, I have been making some calculations as to the comparative wear and tear of the road by horses' feet and coach-wheels; and I consider that the tear and wear of the horses' shoes is very much greater than that of the tires of the wheels. I know it to be so. A set of tires will run 3,000 miles in good weather, or on the average 2,700 miles; while a set of horses' shoes will travel only 200 miles. Take the square inches of the rubbing surface: I think the rubbing surface of the wheel, on an ordinary road, to be somewhere about sixteen square inches; I am taking a gravelly road."

"Do you mean to say that if a coach was standing still, there would be a segment of the wheel of eight inches touching the ground?"—"On a gravelly road it is about that; and I take the average of sixteen square inches, because all tires are not limited to two inches width: some of them are a little more; I take sixteen inches as the standard on the average quality of roads."

"Having measured that part of the wheel which touches the road?"—"I cannot say that I have put my rule to it; but I mean to say a segment of eight inches is pretty accurate. If it is on a perfectly hard road, in dry weather the road will almost be a mere tangent to the circle; but on a soft road, in damp weather, the wheel will make more or less of a rut, and the average depth of the rut will give the segment."

"Will you give the proportion of surface for the horses' feet?"—"I think twelve square inches superficial for one horse-shoe. I cannot say that I have measured it."

"What is the weight of the carriage which you say imbeds itself eight inches?"—"I take the weight of the ordinary post-coaches, when fully loaded, to be somewhere about three tons. I principally rest my opinion, as to the comparative tear and wear, upon the wear of the horses' shoes when compared with the wear of the tires. A horse, after a run of 200 miles, must be shod; and after a run of 3,000 miles, in dry weather, a coach must have new tires."

"From thence you infer, that the wear of the two is in proportion to those numbers?"—"I think it must be thereabout; that is, setting aside altogether for the present the consideration, that the horse's movement is a series of thumps and picks, while the wheel is a roller."

"Is not the iron of the wheel thicker than that of the horse's shoe?"—"Yes; to keep the wheel firm."

"Do you not infer, from the action of the horse's hoof upon the road, that the injury would be great in proportion?"—"I think that the action of the horse's foot on the ground is more destructive to the road: there is more tear and wear to the road by the horse's shoe than by the tire. In rolling two tons along the ground, on four wheels, there will be less damage done than by driving four horses without drawing any thing after them along the same ground."

"Have you made any observations as to the relative wear of the shoes of riding horses compared with those of horses employed in carriages?"—"No; I now speak from circumstances which came to my knowledge when I was connected with running a stage."

"Have you had an opportunity of comparing the wear of the wheels of a steam-carriage with the wear of the wheels of a carriage, supposing they run equal distances and carry equal weight?"—"I have seen Mr. Gurney's proceedings from the beginning to the present time, and in riding with him, I have very narrowly observed the driving wheel to see whether it ever made a surge, (that is to say) made a slip or missed its hold of the ground, and that has so seldom happened, that I do not think it can do much more injury than any other wheel, indeed I might say none; if it does, it is very trifling."

"You speak of the propelling-wheel?"—"Yes."

"Do you know the weight of Mr. Gurney's carriage?"—"I know the weight of Mr. Gurney's carriage from having been told. I take the weight of Mr. Gurney's present locomotive engine, when it carries six or eight persons, to be nearly as heavy as an ordinary four-horse carriage without the weight of its horses; that is, about three tons with coke, water, and passengers."

"Are you speaking of the comparative injury to the roads done by Mr. Gurney's carriage and a four-horse coach?"—"Yes."

"Which do you think does most injury to the road?"—"I should think it must be the same thing, carrying a great weight on any four wheels of equal diameters and surfaces; it will amount to the same thing."

"Does not that suppose that the tire is of the same width?"—"I take the tires to be the same."

"That is independent of the four horses?"—"Yes."

"Then the injury done by the four horses is in addition?"—"Yes."

"Have you observed what the proportion is of the damage done by four horses drawing a coach and the four wheels of a coach?"—"I cannot say that I have made any observation upon that, further than the tear and wear of the shoes, and the tire. I have seen the ruts in a narrow road and the horses' path between them; viewing these and viewing the towing-path on the side of a canal and between the rails of rail-road, I should think that the horses do fully more harm than the wheels."

"Do you think that the action of the horses' feet on a towing-path will do more injury than on a road?"—"Yes; but the action of a horse's feet on a towing-path is not quite the same as when he is carrying a weight or pulling a weight directly after him. The horse hauling on a canal has a motion sideways, and leans to the side farthest from the boat, platting his feet; this is a more destructive action than that of horses' feet on a road."

"Have you found that there is any tendency to slip in Mr. Gurney's carriages in going up a hill covered with new stones?"—"When the surface of the road is not firm, there is a tendency to slip; and when I said there was merely a fraction more of injury done by that wheel than by the others, I was taking such cases into account."

"Do you think that the injury that steam-carriages do to the roads will be exactly in proportion to their different weights, taking the same breadth of the tire?"—"I cannot state the proportion; if you increase the weight, you must increase the breadth of the tire; at different speeds the injury will differ."

"Taking the same breadth of tires, and the same velocity, do you conceive the injury to the road increases in exact proportion to the weight; for instance, that a steam-carriage of two tons will do only half the injury that a coach of four tons would do?"—"I do not know that it will be exactly in these proportions, but it will be somewhat similar."

"Then supposing that a steam-coach carrying two tons had tires of a breadth of three inches, and that a steam-coach carrying four tons had the tires of the wheels of the breadth of six inches; do you think that the injury would be proportionate?"—"I think that there would be nearly the same amount of injury."

"Suppose you increase the weight so as to break through the crust of the road?"—"If you put a very heavy weight, you will break the crust of the road altogether, no doubt."

"Do you think that could be obviated by increasing the breadth of the tire of the wheel?"—"To a certain extent; but you may increase the weight so much as to pulverize the material of the road, even with a broad tire."

"Have the observations you have made been founded on actual experiment or not?"—"It is on observation; I have observed the action of Mr. Gurney's wheels very narrowly on the roads, because I was interested in another patent that was to introduce propellers in the middle of the locomotive-engine, as shown in the drawing produced."

"Have you observed them under different ascertained weights?"—"No great variety."

"Upon an ordinary road is the injury done by a stage-coach or by a steam-carriage so great as to be apparent at each time that carriage travels along the road?"—"Whenever you see a mark left by a wheel you are entitled to say there is an injury done to the road to the extent of the rut."

"Do you state that if it is merely a mark on the soft surface of the road?"—"Yes; from the wheel being at all imbedded in the soil; the water gets in and soaks its way through. If it is in frosty weather, the water and the damp get down, and the alternate freezing and melting destroys the road."

"In an ordinary road is the impression of the wheel of a stage-coach upon the solid surface of the road so great as to make the injury apparent every time the carriage passes over it?"—"It is apparent to me, because wherever there is a mark upon the road there is a consequent injury."

"Whether that mark is merely the impression of the wheel on the soft mud or dust, or by crushing the materials?"—"Wherever the road is damp, the consequence of the mark, however slight, tends to destroy the road."

"Do you mean whether on the soft mud on the road, or on the solid substance?"—"The road must be destroyed to some extent; I do not say that it is perceptible. If you put out of consideration the surface, the mere mud, it is not perhaps perceptible at the time; but there must be tear and wear going on on the road, or it will last for ever. I do not now talk of the action of the elements."

"On what data do you state that the steam-carriage does not do more injury than the wheels of a stage-coach?"—"Because it does not make a deeper rut."

"Does either of them make a rut?"—"If you suppose the road to be a concrete mass, and that there is merely a little mud and dust on the top of it, I cannot prove that a four-horse coach does any perceptible injury to that road. I will say also a steam-carriage will, in a similar case, do no perceptible injury to it."

"Of course if the road was composed of solid rock you would not be able to tell whether a coach of any description had gone over, there being no mark left; but talking of ordinary turnpike-roads, should you be able to trace the indentation that coach made?"—"Yes."

"Would you not be able to do the same with a steam-carriage?"—"Yes; there are some roads in England, a part of the Holyhead road, for instance, so well made that you cannot trace any vestige of injury done in good weather. A part of Mr. Telford's road there is a concrete mass."

"Do you know whether that road has ever been mended since it was first made?"—"I suppose it has[1]."

"Should you not say that the injury done to the road by a carriage passing over it depends greatly on the state of that road, whether damp or dry, or otherwise?"—"Certainly."

"Are there any states in which a road is placed in which no injury is done by a carriage passing over it; take the case of a hard frost for instance?"—"No perceptible injury is done in that case, if the road is so hard that the wheel makes no mark upon it. But where the road is at all soft, and when the wheel sinks into that road, it must tend to destroy the road: if it be merely in mud on the surface of the road, it is making a cistern to hold a puddle of water."

"The greatest injury done to the road will be just after the breaking up of a frost?"—"Yes; or in fact after the effect of the frost, the water having got into the interstices, has been frozen and expanded. When it thaws, the road is not so compact; it is soft and pulpy."

"That is the state in which the greatest injury will be done to the road by a heavy weight passing over it?"—"Yes."

"Have you ever, in such a particular state of the road, observed the injury done by a stage-coach drawn by horses, and that by a carriage propelled by steam?"—"I have seen the locomotive-engine travelling in the month of January, and also the ordinary carriages, and I cannot see that the locomotive-engine has done any more injury than an ordinary carriage. The destruction on the road after a frost is much greater than in other cases."

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[1] I since find in a paper, which Mr. M'Neil read before the Institution of Civil Engineers, it is stated, that "on a part of the Holyhead road, made five years ago, there has not been a stone put since, and the wear is very trifling. Hardly any mud has been scraped off, and in summer it produces little or no dust."

"Have you made observation as to the effect on the road by each carriage when the road was in the worst state?"—"I have seen them exactly at the same time and in the same circumstances. In the month of October, when there had been a considerable deal of rain, and the old road to Barnet, down by Stanmore, was very soft in consequence of the rain, I have seen the effect of a locomotive engine, and the effect of the Hemel Hempstead coach, running alongside of each other, and I consider that there was no difference at that time; I was then watching the action of Mr. Gurney's wheels, and particularly his driving-wheel, with that view. I put the horses out of the case."

"Was there any perceptible difference in the damage done?"—"None, that I perceived."

"What are the effects on the wear of the road, by increasing the velocity of the steam-carriage?"—"I have not observed that, but it must be less. Suppose you are carrying a weight on a road slowly during a frost, you will break the crust; but travelling at a greater rate over it, it will not have that effect; the frozen crust will remain unbroken."

"Have you observed the effect on the road, by increasing the diameter of the wheels?"—"I cannot say that I have seen that."

"In Mr. Gurney's carriage, the wheels do not always follow in the same track?"—"Sometimes they do, and sometimes they do not."

"Under those circumstances, supposing equal weights on the four wheels, it would be easy for you to observe whether the wear of the fore and hind-wheels was the same?"—"I never observed any perceptible difference in the injury."

"A considerable proportion of the wear of the road is to be attributed to the atmosphere, without reference to the carriages which pass over it?"—"Yes; the most destructive element in nature is water; and, in the course of the winter, the action of the water that gets sucked up into the road is very bad [1], and the very washing is also very bad."

"Are there many states of the road in which a wide tire is of considerable advantage to the road?"—"Yes."

"In the majority of cases do you think the superior width of the tire which the steam-carriage has over a carriage drawn by horses is altogether an advantage or a disadvantage?"—"A wide tire has the advantage upon the average."

"And the steam-carriage has that advantage over the other?"—"Of late Mr. Gurney has increased the width of his tire; it was at all times wider than other carriages, but he has increased it still more."

"Does the width of the tire impede the velocity at all?"—"Scarcely in a perceptible degree."

"Are you of opinion that a wide tire, under any circumstances, does

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[1] The powerfully destructive effects of water under changes in the atmosphere are well known in the rending of rocks; and the poor Canadian has often suffered loss of life and property by the falling of his house from a foundation destroyed by atmospheric changes.

injury to a road in any state of it?"—"I have made no observation as to its doing an *injury*."

Mr. Telford, President of the Institution of Engineers, examined. (Report, p. 79.)

"You are aware that the object of this committee is to ascertain, as far as practicable, how far the operation of carriages propelled by steam upon public roads is more or less injurious than the operation of carriages drawn by horses?"—"I have never had any experience of steam-carriages upon roads, and therefore I cannot say experimentally what effect they will produce; but if there is no projection upon the surface of the wheel, and they are not suffered to drag upon the road, it does not appear to me that any injury can arise more, but rather less than by common carriages."

"Do you consider that supposing the weight of a steam-carriage were equal to that of a carriage drawn by horses, that is two tons each, the injury done to the road by horses or by the carriage would be the greatest?"—"I should expect that by the horses."

"In a much greater degree, do you conceive?"—"I cannot exactly say the proportion, but I should think the greatest degree of injury arises from the horses' feet."

"What is the nature of the injury done to roads by the travelling of carriages and horses?"—"By the horses chiefly by tearing up the surface with their shoes; I do not consider that the pressure of the wheels upon a good made road is nearly so injurious to the road as the tearing up of the road by the horses' feet."

"Supposing that the operation of a steam-carriage were so perfect that there should be no sliding of the wheels, and that such steam-carriage were of four tons weight, and also that the joint weight of a coach and horses were four tons travelling at equal velocity and with equal breadth of tire, which do you think would do the least injury to the road?"—"I should think that the steam-carriage would do the least injury, but that is not from experience of steam-carriages, but only from my general information, always taking for granted that there is no projection outside the wheel."

"If under those circumstances the breadth of the tire of the carriages drawn by horses were two inches and a half, the usual breadth, and the breadth of the tire of the steam-coach were four inches, should you then have any doubt which would do the least injury to the road?"—"I have already said if the tires were equal, I conceive the steam-carriage would do the least injury, and certainly the chance of injury will be lessened if the tire is made double the breadth."

"If the breadth of the tire of the wheels of steam-carriages could be extended to six inches, might they not in many states of the roads be rather beneficial than injurious?"—"Where the road is properly made of good materials and well consolidated, the mere pressure of a carriage would not have any effect."

"Do you think it would be fair to impose an equal toll, weight for weight, on steam-carriages and on carriages drawn by horses?"—"I think it ought not to exceed that."

"Do you think that it ought to be equal, as the one carriage you state does not do so much injury as the other?"—"In justice it ought to be diminished, but that is only opinion until it is proved."

"Have you paid any attention to the mode of charging toll on steam-carriages?"—"I have not."

Mr. James M'Adam examined. (Report, p. 89.)

"Have you had considerable experience in road-making, and superintending roads?"—"Yes, for the last fourteen years."

"Have you made any experiments, or are you able to give any information to the committee, as to the comparative wear of roads, or injury to roads by carriages and horses passing?"—"I have generally found that horses' feet do very great injury to the surface of a well-made road; and I am of opinion, that a carriage with properly-constructed wheels does less injury to a road than the horses drawing."

"Would you explain what the operation of the injury done to the road is by travelling on it; is it the wear of the road, or the displacement of the materials?"—"Both take place; the wheels to a certain degree wear out the material, but upon a road properly constructed, and that has become consolidated, and the surface smooth, that wear is very small and gradual; the injury to the road from the horses' feet, more especially upon gravel and flint roads, arises particularly in dry weather from the knocking up and displacing the materials upon the surface, and each succeeding journey adds to the evil, and were it not for the effect of the wheels following the horses in mitigation of that evil, we should have the flint and gravel roads all loose throughout the whole summer."

"But the wheels of the carriage do not actually follow in the track of the horses?"—"But in roads of much thoroughfare, especially near the metropolis, other carriages do."

"What proportion of the injury to the road do you think takes place from the changes of the atmosphere; frost and wet, have they any material effect?"—"Yes, decidedly, in chalky soils in particular: at Royston and through that country a great and serious injury takes place upon the breaking up of all frosts, nor can we, by any care or attention or strength of surface of the road, prevent that taking place; it comes in a very eccentric manner, and breaks up one year at one part of the road, and another at another, occasioned in a great measure by the standing of the water in the sub-soil; and I suppose also, by the way in which the wind is at the time it freezes. It is the modern practice of road-making to abstain from all general repair of the roads from the middle of April until the middle of October; during that period the only repairs that ought to take place are partial coatings, necessary from accidental circumstances. As soon after the middle of October as possible the general coating takes place in pieces of the road at a time so as to interfere and interrupt as little as possible general travelling, and we endeavour, by the month of February, to have the whole of the coatings put on; in no instance above a sixth part at a time."

" Have you witnessed the operation of a carriage propelled by steam on the public roads?"—" I have observed it; but in a small degree."

" Who was the proprietor of the carriage you noticed?"—" I think it was Mr. Gurney's; I accidentally saw it."

" Then you only saw it once?"—" Only once."

" What was the state of the roads when you saw it?"—" Tolerably good at the time; I saw it in the Regent's-park."

" Were they in such a state you could make any observation upon the greater or less injury produced by it than by a common carriage?"—" I cannot say that my attention was directed at that time to that fact; I have not had an opportunity practically of seeing the effect of steam-carriages upon roads; there have been none used near us except passing down to Virginia Water, &c.; but not being brought into general use, I have not seen sufficiently the effect of their wheels upon roads."

" From the experiments you have before stated, what should you recommend should be the breadth of the tire of the wheel of a carriage with four wheels weighing four tons?"—" I consider that a carriage of any description required to carry a great weight, five or eight tons, ought to have a wheel of four inches and a half in breadth, constructed agreeably to the clause in the Metropolis Act; and I consider that a carriage with such a wheel, though carrying an excessive weight, would do very little injury to the road."

" It has been stated by a previous witness, that a carriage of the weight of two tons, propelled by steam, drew after it another carriage weighing nine tons; what should, from your experience, be the breadth of the tire of the wheel of the propelling carriage and the carriage drawn?"—" Looking solely to the welfare of the road, I should prefer a wheel of four inches and a half, flat on the tire, to any other class of wheel that can be made, being of opinion that a greater breadth of wheel cannot at one time touch the surface of a well-formed turnpike-road."

" Then you would prescribe that breadth as the minimum breadth of wheel for any weight?"—" Yes; I do not think any increase of breadth would be of any service."

" Supposing two carriages, one drawn by horses, and the other propelled by steam, the weight of the steam-carriage being four tons, and the weight of the carriage drawn by horses being two tons, which would do most injury to the road, provided the breadth of the wheels were the same in both cases?"—" I should prefer, with a proper wheel in both cases, the steam-carriage without the horses, because that question can only be answered with reference to the wheel."

" Then, in the case given, if the wheels of the steam-carriage were four inches and a half, and the wheels of the coach two and half, which would do the greatest injury?"—" The coach, decidedly, drawn by horses, though only two tons and a half, infinitely more; because I consider, that of all classes of thoroughfare at present, the stage-coach, as usually laden, does us the greatest injury."

" Can you suggest any mode by which tolls could be fairly charged on steam-carriages, in relation to the tolls charged on coaches?"—" The mode adopted in coaches, of taking toll per horse as well as waggons, has been found to answer every purpose, it being, in truth, a penalty upon weight. If greater weight is put upon a waggon, a greater number of horses are necessary to move it, and the parties bring the penalty in the shape of toll in their hands. This cannot be applied to steam-carriages, and I am at a loss to recommend to the Committee any general mode, unless the diameter of the cylinder or power of the engine could be taken. In the Metropolis Act of 1829, there is a toll laid upon steam-carriages; any carriage that shall be in any manner drawn by steam or gas shall pay the toll that would be paid by any carriage drawn by four horses."

"If the power of the engine is equal to any number of horses you only charge the same toll?"—"The same toll."

"Then if a steam-carriage drew another carriage after it, or two carriages after it, would it be two or three tolls, or one only?"—"Two or three tolls: where a steam-carriage conveys passengers by drawing another coach they would each pay the toll of four horses; this is a matter still in its infancy: in many Acts, such as the Lemsford Mills Act, a toll of half-a-crown was introduced for any carriage drawn or propelled by steam."

"Would not this inconvenience arise from the clause you have read in the Metropolis Tolls Act; it would be a premium given in favour of one description of steam-carriage over another, though the injury done to the road might be in favour of the one less taxed, as in the case of a steam-carriage carrying twenty passengers, and another steam-carriage drawing a carriage containing the same twenty passengers?"—"In that case the toll would certainly be an unjust one, and require revision; it was a point not settled, and it was put in merely to commence the toll, and call the public attention to it. I beg leave to observe, that if these carriages come into general use, they would necessarily require a still greater perfection in the surface of our roads, and also in the levelling of the remaining hills; as good surface and little inclination is to them of the greatest importance."

"If that is the case, would it not be necessary to lay considerable rate of toll upon those carriages, for the purpose of affording the means of executing those improvements?"—"It is found, that lowering the hills, and improving the surface of all the roads, is productive invariably of a great increase of thoroughfare; and although lowering the hills might be attended with the first expense, any excitement that would induce the trustees of the roads to keep them in good order would be at the same time productive of economy, a good road being always the cheapest."

"Do you not suppose, if those carriages were in general use, the very action of the wheels upon the roads would prevent the necessity of such frequent repairs as are required at present?"—"I should think that the absence of the horses' feet in a great degree upon the roads would be a very considerable saving; and I have already stated, that these carriages, with properly constructed wheels, would be the class of carriages that would do the least injury to the roads."

"What is the greatest speed you have known a carriage drawn by horses to execute a given number of miles on your trust?"—"I once, by mere accident, came in the Leeds Union coach from Grantham, which is 110 miles from London; I got into the coach at three o'clock, and I was in London at h [illegible] ame morning; that was at the time the Leeds Union and th [illegible] re racing the whole way up."

[illegible] hat Mr. Telford states in his Report on the state of the Hol [illegible] three of the Birmingham coaches perform the journey of 1 [illegible] n eight hours, without any accident, at the rate of thirte [illegible] longs an hour?"—"I have frequently heard it stated upon t [illegible] lo not know it of my own personal knowledge."

"Hav [illegible] ther observations you would wish to make to the Committee?"— [illegible] am not aware of any point."

"You do not think it will be necessary to limit steam-carriages to any particular number of passengers, provided the wheels were of the dimensions stated?"—"If the wheels were of the dimensions and the description stated, I should, in reason, be regardless of weight, experience having completely proved, with properly constructed wheels, we sustain little or no injury from weight."

"What is the maximum weight a road would bear upon each wheel?"—"The injury done by weight upon a road in a carriage with proper wheels is principally, I might almost venture to say exclusively, to the new coatings; if the weight in such carriage is a crushing weight, as applied to the materials with which the road is made, it does a very considerable injury, and therefore were steam-carriages to become in general use, it would be a matter of great importance, that harder metal should be introduced, that flint should take the place of gravel, and that granite or whinstone take the place of flint, which is the principle acted upon by the commissioners of the metropolis roads, but upon a hard and well-consolidated road a very great weight may be sustained without doing comparitively any injury."

"When you state that if steam-carriages come into general use harder materials ought to be used, you suppose that these steam-carriages will be much heavier than the carriages used at present?"—"Yes; I contemplate that they will carry much greater weights."

"Your answer does not apply to carriages that are of the same weight as those now used?"—"No; but to carriages of the weight of eight or ten tons; when I spoke of the weight of from eight to twelve tons, I supposed a carriage with four wheels."

"Upon the present well-constructed roads what weight do you think could be put upon them without crushing them?"—"I should not apprehend any injurious result from the general use of steam-carriages with properly made wheels, carrying upon an average from eight to ten tons."

"Your answer refers to roads that are so well made that the whole pressure shall be as that of an arch, but on the average of roads, such as shall be found in the country, would you give the same answer?"—"No, certainly not."

"Taking the average of any line of road for a great number of miles, where materials less capable of bearing weight must necessarily be used for a considerable proportion of that road, what should you say is the maximum weight that should be allowed with reference to the preservation of that road on any one wheel of four inches and a half?"—"Two tons."

"Have you ascertained that by experiment?"—"I have not had an opportunity of judging of it, except in all the waggons that depart from the metropolis that are required to have the wheels constructed in the way I have described, some of which carry considerable weights."

Mr. John M'Neil, civil engineer, Daventry, called in and examined. (Report, p. 93.)

"State your profession?"—"A civil engineer; I am at present the resident and assistant engineer, under Mr. Telford, to the parliamentary commissioners, on the Holyhead Road between London and Shrewsbury, and London and Liverpool."

"What is the weight of a coach, a van, and a waggon, each carrying what would be considered an average load; state also the breadth of the tires of their wheels?"—"The weight of four-horse stage-coaches varies from fifteen cwt. and three quarters to eighteen cwt.; most of the Birmingham day and night coaches weigh about sixteen cwt. and frequently carry, the night coaches in particular, upwards of two tons of goods and passengers, exclusive of the coach; yet, taking into consideration the number of times they travel with very light roads, I should say that from two tons five cwt. to two tons ten cwt., including the carriage, would be a fair average weight during the year. The tires of the wheels are mostly two inches, but some of them are less; those constructed by Mr. Brown, and used on his patent coaches, have the edges chamfered off, so as to give a flat bearing of one inch and a half; but from the peculiar manner in which those coaches are mounted with springs, I am inclined to think the injury done to the roads by these wheels is not so great as it otherwise would be. Some coach-wheels that I have seen are rounded off, so as to form in the cross section a segment of about one inch and three quarters in diameter. The bearing in this case on the road, where the surface is hard and smooth, is reduced almost to a point, and must be extremely injurious. The coachmen remark that carriages with such wheels run wild in descending hills in summer, but heavy in winter, and when the roads are soft and muddy. The mail-coaches weigh very nearly twenty cwt. Some of them, the Holyhead coach for instance, frequently carries upwards of a ton of letters and parcels, independent of passengers and their laggage. The average weight of the whole may probably be taken at two tons. Some others, the Liverpool day mail for instance, travel very light, and probably will not average one ton and a half. The breadth of tire of mail-coaches is two inches and a quarter; the four-horse vans, which travel about six miles an hour, weigh on an average four tons and a quarter, including the carriage; the breadth of tire of one which I measured was two inches and a half, but I am not prepared to say that this is the general size of such wheels: the horses used in these carriages are of the very best and largest description, which added to so great a weight on narrow wheels, probably renders this carriage more injurious to the public roads than any other description of vehicle at present employed. There are four descriptions of waggons in general use, the eight-horse waggon, the six-horse waggon, the four-horse waggon, and the farm waggon, which is drawn sometimes by two, three, or four horses, according to the load. The eight-horse waggons, though frequently weighing, with the load, seven tons, may probably be averaged at not more than six tons the year round; the wheel is nine inches in the tire, but from a very improper plan followed in its construction the bearing on a hard solid road is only three inches, for these wheels are generally shod with three hoops of three-inch iron, the centre one of which is of a greater diameter than the others, and projects full half an inch beyond them, which on weak roads, such as in the neighbourhood of London, must be most injurious. I have measured one since I came to London, which travels on the Bath and Bristol road; the outer rim is conical, and can certainly never come in contact with the road surface, unless it be one on which the wheel would sink two or three inches; the six-horse waggons, with their load, generally weigh four tons and a half; their wheels are six inches wide, and of a better description than the former, though sometimes one of their hoops projects beyond the other, as in the case of the nine-inch wheel; the four-horse waggons, with their load, commonly weigh three tons and a half, their wheels are four inches wide, and are more upright than the others, and have a more level bearing on the road; the farm waggon, used in Northamptonshire, weighs on an average one ton one cwt., the breadth of a wheel is three inches, and it carries from one ton to three tons, according to circumstances, and lasts nearly twenty years."

"On an average line of road of not less than 100 miles, on which in many places materials of very inferior description must have been used, both in its formation and subsequent repair, what is the maximum weight per wheel (say if not less than four inches width of tire) which should be carried on any kind of carriage (carriage weight included,) without risk of injury to the road?"—"On a road, such as here described, the injury will be considerable by any wheel passing over it; but without a more defined statement of the quantity and quality of the materials used, I do not think this question can be answered with any degree of certainty; on all gravel roads, however made, without a foundation or bottoming, I should say the weight on a four-inch wheel should not exceed fifteen cwt., and on a wheel less than that ten cwt. on the generality of roads, throughout the country; I do not think it would be safe to run a carriage with almost any width of wheel if the load much exceeded ten tons; in fact there are some bridges even between London and Birmingham, that it would be running a risk to pass over with a carriage weighing ten tons."

"Can you from observation say what proportion the breadth of the tire of wheels should be to the weight?"—"The breadth of tire, in proportion to the weight, will depend entirely upon the description of road over which the carriage passes; on such a road as that lately constructed by the parliamentary commissioners of the Holyhead and Liverpool roads, at the Highgate Archway, I have frequently observed waggons carrying upwards of six tons pass over it; the weight of each wheel on the road was then about thirty cwt.; and though the bearing of the wheels, from the cause I have before stated, was not more than three inches, the effect produced was imperceptible; the pressure in this case was ten cwt. on every inch, which is unquestionably too much for the generality of roads; but if we take the road from London to Shrewsbury, as a criterion to judge by, I should say that a wheel ought to be an inch in width for every ton that a carriage and its load would weigh; and that if every carriage that now travels that road was limited not to exceed that proportion, the roads would be better, and maintained at a cheaper rate than at present. According to the average weight of coaches and waggons, as before stated, I have calculated the following table, showing the weight at present carried on each inch of bearing, and what I conceive might be the breadth of the different wheels if they were made cylindrical with an even bearing, and in the proportion of one inch of width for every ton, including the carriage."

Description of Carriage.	Velocity in miles per hour.	Weight, on an average, in tons.	Breadth of the Wheels, in inches.	Pressure of each Wheel, in cwts.	Pressure on each Inch, in cwts.	Breadth of Wheel, calculated in the proportion of 5 cwt. to the inch.
Mail Coach	9 to 11	2	2¼	10·0	4·40	2
Stage Coach	8 to 11	2½	2	12·5	6·25	2½
Van - -	6 to 7	4¼	2½	21·25	8·29	4¼
Waggon -	2½ to 3	6	9	25·0	2·77	6
Ditto - -	2½ to 3	4½	6	22·5	3·75	4½
Ditto - -	2½ to 3	3½	4	17·5	4·37	3½

"State your opinion as to the relative wear of a road by two carriages, both drawn by four horses, one carriage of two tons weight, with two-inch tires, the other four tons, with four-inch tires?"—"My opinion is, that the wear of the roads would in each case be the same, as far as it was affected by the wheels of the carriages, probably rather less, by the carriage carrying four tons, on four-inch wheels, than by the carriage carrying two tons, with two-inch wheels; but it must be recollected that both the carriages are supposed to be drawn by the same number of horses, and as the horses drawing the carriage of four tons must use greater exertions than those drawing the carriage of two tons, I am of opinion that the aggregate wear of the road would be more by the transit of the four ton carriage than by that of the carriage weighing two tons."

"How would the foregoing answer be affected by an increase or decrease of velocity in either carriage?"—"If the road over which the carriages are drawn be hard, solid, and smooth, I think there would be very little increase of wear from the effect of the carriage-wheels by an increase of velocity; but if the road should be uneven or rough, there would be an increase of wear, in consequence of the impetus or blow with which the wheels would strike the road, after passing over the inequalities in its surface, particularly if the carriages were made without springs; but whether the road be a good or a bad one, the wear occasioned by the feet of the horses will be greater when they travel with an increased velocity: for a coach-horse, which travels at the rate of ten miles an hour, works on an average 270 miles in a month, and wears out in that time about four pounds of iron in shoes; whereas a waggon-horse, which travels at the rate of three miles an hour, and works twenty-six miles a day, for four days in the week, goes, on an average, 416 miles in the same period of time, and wears out 4.8 pounds of iron. If the coach-horse travels the same distance, the wear would be six-sixteenths, which exceeds the wear of the waggon-horse one-thirty-sixth. In the same way might the relative injury caused by the wheels of the waggon and the coach be ascertained."

"What is the operation of the atmosphere on roads?"—"Well made roads, formed of clean hard broken stone, placed on a solid foundation, are very little affected by changes of atmosphere; weak roads, or those that are imperfectly formed with gravel, flint, or round pebbles, without a bottoming or foundation of stone pavement or concrete, are on the contrary much affected by changes of the weather. In the formation of such roads, and before they become bound or firm, a considerable portion of the sub-soil mixes with the stone or gravel in consequence of the necessity of putting the gravel on in thin layers; this mixture of earth or clay, in dry warm seasons, expands by the heat, and makes the road loose and open; the consequence is, that the stones are thrown out, and many of them are crushed and ground into dust, producing considerable wear and diminution of the materials; in wet weather also, the clay or earth, mixed with the stones, absorbs moisture, becomes soft, and allows the stones to move and rub against each other when acted upon by the feet of horses or wheels of carriages. This attrition of the stones against each other wears them out surprisingly fast, and produces large quantities of mud, which tend to keep the road damp, and by that means increases the injury."

"Supposing the actual wear or deterioration of a road to be represented by 100, and that only coaches, vans, and waggons have passed over it during any given period, in what proportion would you estimate the effects; first, of atmosphere; secondly, of the carriage; thirdly, of the horses?"—"This question can only be answered in a general way; no two lines of road would probably give results at all similar; much will depend on the manner in which the road is constructed, the materials of which it is composed, the care bestowed on its drainage, and whether it be in an open situation or shaded by trees; if the road be properly made, and in an open situation, the injury arising from the atmosphere will be little, compared with the actual wear caused by the wheels of carriages and the feet of horses, probably not ten per cent. during the year; whereas on weak roads, in clay countries, every shower loosens the materials of which the road is composed, and causes considerable wear, perhaps thirty per cent., or even more in some situations, where the road is shaded by trees. To get at something like an average proportion between the wear occasioned by horses' feet and the wheels of carriages, I have procured the following facts: the coaches which run between London and Birmingham required an hundred horse on an average, to work the up and down coach; the horses are generally shod by contract, at about 2*s.* 6*d.* per horse per month; those near London are much larger and heavier, and therefore require heavier shoes than those twenty miles out of London, and from thence to Birmingham; near London, in the flint districts, the wear of horses' shoes is much more than it is in the quartz and limestone countries. At Stony Stratford, the weight of the four shoes of a mail and stage coach-horse averages five pounds, and when taken off at the end of about twenty-eight days they weigh very nearly two pounds: in this period, the horses run 252 miles. At Towcester, Weedon, and Daventry, the weight of the new shoes is one pound and a half each, and when taken off weigh nearly three-fourths of a pound; the length of time which they remain on is about thirty days; this would give a wear of three pounds per horse per month; but if the greater wear near London be considered, I think it would not be too much to allow the wear equal to four pounds per horse per month, which, for 100 horses for ten weeks, would give a wear of 1000 lbs. of iron. The hind-wheels of the coaches are mostly four feet eight inches in diameter, and the front wheel three feet. The width of tire, I before stated, is about two inches, and when new, the thickness of the iron is three-quarters of an inch. These wheels are found to last from two to three months, according to the state of the weather, the workmanship, and quality of iron, (about twenty years ago, they did not last seven days on an average;) suppose they now last ten weeks, in that time the tire is worn down to one-sixth of its original thickness; this would be equal to 163·4 lbs., or 326·8 for both coaches; this would be to the wear of the horses' shoes, as 326·8 to 1000, or as 1 to 3-14ths nearly. Now if the injury done to the road by the horses' feet and the wheels of carriages be estimated in the same proportion, I think it would probably be near the actual effect produced; that is to say, the injury done by the wheels of fast-coaches is, to the injury done by the horses which draw them, as one to three in round numbers. The effect produced by slow carriages and horses is different: a waggon drawn by four horses, which travels regularly from London to Daventry, at the rate of three miles an hour, is worked by fifteen horses; the waggon weighs twenty-five cwt., and carries, on an average, sixty-seven cwt.; the hind-wheels are four feet eight inches in diameter, and the front ones four feet; the breadth of the wheels is six inches; they are nearly upright, but not cylindrical; the iron tire, when put on, weighs, on the fore-wheels, 285 lbs.; on the hind ditto, 396 lbs.; making 621 lbs. When removed, the weight is, on the fore-wheels, 144 lbs.; on the hind ditto, 168 lbs.; making 312 lbs.: wear in five months, 309 lbs. The number of miles travelled in this time is 6048; the shoes that are put on the horses employed to draw this waggon weigh, when new, from two pounds and a half to three pounds each; the average of a great many gave two pounds and three-quarters, and when removed, one pound and a quarter; they last from four to six weeks, according to the weather and state of the road; but we may assume five weeks as an average, and the wear in that time for each horse six pounds; and for fifteen horses, for five months, it would be 360 lbs. The proportion, in this case, would be as 309 to 360, or as one to 1·16, or nearly one to 1¼; on the generality of roads, therefore, I would say, the proportion of injury would be nearly as follows, when travelled by fast-coaches:—

Atmospheric changes	20
Coach-wheels	20
Horses' feet that draw them	60
	100

And when travelled by waggons:

Atmospheric changes	20
Waggon-wheels	35·5
Horses' feet that draw them	44·5
	100"

"What is the effect of travelling by coaches and horses; whence and in what proportion does the injury or deterioration arise; the crushing of materials; their actual wear; their displacement?"—"If the wheels of carriages be properly constructed, and cylindrical, the friction, and consequently the wear, on the surface of a well-made road, will be very little, and there will be no injury from displacement of materials, except what may arise from the few surface-stones that will sometimes be started out by the feet of horses on steep hills, when they are obliged to exert a great force to draw up a heavy load. When stones are thus thrown out on a hard and solid surface, the wheels of heavy carriages will crush them, and cause an injury which would be much more than that caused by the actual wear of the wheels passing over the surface. If the roads be weak or elastic, and bend or yield under the pressure of the wheels, the particles of which it is composed will move and rub against each other, or perhaps break by the action of heavy wheels over them. On such roads, I conceive the injury caused by steam-carriages will be much greater in proportion to the injury caused by light carriages drawn by horses, than it will be on solid firm roads. In one instance, where an accurate experiment was made, the wear was found to be four inches of hard stone, when it was placed on a wet clay bottom, while it was not more than half an inch on a solid dry foundation (formed as described in the Report of the Select Committee on the Holyhead road, on the 30th May, 1830), or with a pavement bottom, on a part of the same road, when it was subject to the same traffic. On the Highgate Archway road before mentioned, the annual wear does not appear to be more than half an inch in depth. Now as this road is very little affected by wet, in consequence of its peculiar construction, and the care bestowed on its drainage, I attribute almost the whole of the diminution of materials to actual wear. On many roads, where the sides are weak, great injury arises from the crushing of materials, particularly by the action of waggon-wheels. In frosty weather, weak roads very frequently suffer more in one month than all the rest of the year. In such cases, the injury is caused by the wheels of carriages, and not by the horses' feet."

"If 30 lbs. be sufficient to move a carriage of 21 cwt. 8 lbs. on a level platform, little affected by friction, and 266 lbs. be required to move the same carriage up an inclination of one in ten, the pressure in the one case being exactly the weight of the carriage, 21 cwt. 8 lbs., what would be the pressure on the road, or platform on the inclination?"—"As the pressure on the horizontal is to the pressure on the inclined plane, as the length of the plane is to its base, we have this proportion: $\sqrt{b^2+p^2} : b :: W : \frac{wb}{(b^2+p^2)^{\frac{1}{2}}} =$ the pressure on the plane. In this example, $w = 2360$. $b = 10$. $p = 1$, which gives $\frac{\mathrm{w}b}{(b^2+p^2)^{\frac{1}{2}}} = \frac{2360 \times 10}{\sqrt{100+1}} = 2349{\cdot}5$ lbs. or 10½ lbs. less than the pressure on the horizontal."

"Taking twenty miles near London, 150 lbs. appears to be the average force actually engaged in drawing the carriage of 21 cwt. 8 lbs., including hills; would the force required to draw a carriage of 42 cwt. 16 lbs. be on an average 300 lbs., and so on in proportion: the extreme traction of the carriage being 343 lbs., what, on this road, would have been the maximum force required to draw a carriage of four tons weight?"—"It does not follow that because a carriage is twice as heavy as another, that its draught would be twice as much; the resistance arising from gravity on the inclined planes would, abstractedly considered, be double; but that part of the resistance arising from the friction and penetration of the wheels into the surface-materials would much depend on the construction of the carriage, and its wheels, and the different sorts of roads over which it was drawn. In order to ascertain the average draught of a carriage of 42 cwt. 16 lbs. over the above road, I conceive that the friction of the surface, or resistance opposed to the motion of such a carriage, should be ascertained on each description of road within the above limits, and then by knowing the rates of acclivity, or the amount of gravity acting on each, the average draughts might be ascertained, if the same carriage and wheels were used, but loaded so as to make up 42 cwt. 16 lbs., the average draught. It might probably be calculated pretty nearly from the following table of experiments, which, as it may be of use in the present inquiry, I here beg leave to hand in; but it must be remembered that the proportions given in this table between the increase of weight and the increase of draught will not be the same on every description of road. To be enabled to answer the second part of the question, it will be necessary to know the rate of acclivity on which the draught of the carriage weighing 21 cwt. 16 lbs. was 343 lbs., and also to know the draught of the four-ton carriage on the horizontal; but even then a difference might arise from the construction of the carriage, and the situation of its centre of gravity."

TABLE of EXPERIMENTS *made on the* 28*th January*, 1829, *immediately after a rapid thaw; the mud was full one and a half or two inches thick on the road at the time.*

TABLE I.

No. of Planes.	Waggon empty, weight 1 Ton.		Half a Ton in the Waggon.		1 Ton 2 Cwt. in the Waggon.	
	Down.	Up.	Down.	Up.	Down.	Up.
1	30	99	45	145	58	210
2	64	88	105	120	125	150
3	75	85	115	120	135	155
4	75	85	105	115	135	155
5	80	88	105	125	135	165
6	85	93	105	135	135	170

"Neither the rates of acclivity, nor the lengths of the planes, were taken at the time, but it might still be done, if thought necessary by the committee, as the points are well ascertained."

EXPERIMENTS *made on a horizontal Timber Platform in January,* 1829.

TABLE II.

Weight of the Waggon and Load.	Powers required in lbs. to move it.	Difference between empty Waggon and Load.
2,240	29	
2,800	74	45
3,360	104	75^{30}
3,920	140	111^{36}

"If 266 lbs. be required to move a carriage of 21 cwt. 8 lbs. up an inclined plane of one in ten, what amount of weight would be required to keep the carriage stationary, or to allow it to descend with the slowest possible motion on the same inclination. This question has reference to the injury done to roads by 'dragging' the wheels, and subsequently to the slow motion of the propelling wheels of steam-carriages in descending hills?"—"If the base of the inclined plane be 10, and its height 1, the length will be $\sqrt{10^2 + 1^2} = \sqrt{101} = 10{\cdot}05$ nearly, and we have the proportion $10{\cdot}05 : 1 :: 2360 : 234{\cdot}82$ lbs. the weight which would be required to keep the carriage stationary if the surface of the plane was hard and smooth, and the mass collected in a point; but as 266 is stated to be the moving power, the resistance arising from the friction of the surface and the axle-trees would in this case be 31·18lbs.; it may be well to observe here, that the experiments made, on inclined planes, as detailed in the Seventh Report of the Parliamentary Commissioners of the Holyhead and Liverpool road, were not intended for any thing further than to get practical results, the description of which could be easily understood by road-surveyors and their assistants, and even by men in the habit of driving coaches; it could not be expected that experiments made with a large unwieldy waggon, mounted with common axle-trees besmeared with tar, could furnish results on which to found a refined mathematical calculation. I have, however, within these few days, commenced a series of experiments, with a small carriage constructed on purpose, and furnished with a very delicate instrument for measuring the draught. From the little way I have as yet gone in these experiments I cannot furnish any details at present; but I think I am warranted in saying that a very great benefit would arise in the saving of road-materials, by the adoption of a better method of hanging the coaches, in a manner, perhaps, something similar to gentlemen's carriages. Many of these weigh, when fully loaded, two tons, yet a pair of post-horses draw them with apparent ease, the rate of ten miles an hour; and on some parts of the road between London and Birmingham, where the road is tolerably level, at a much greater speed; some of the Birmingham and London coaches travel the same ground at twelve miles, and sometimes fifteen miles an hour. This velocity, however, may in a great measure be attributed to the level and perfect state of that road."

"The details of various kinds of steam-carriages have been given to the committee; all act without propellers; without projection on the wheels, with cylindrical wheels; some with greater or less breadth of tire, even six inches wide; the power is applied either by crank or wheels to one or two propelling wheels, according as greater or less force may be required. Some of the experimental carriages had three, some six wheels; all will have four wheels. Some have the engines in a separate carriage, and draw the load; some carry the load and engines on one carriage. Taking the above circumstances into consideration, which would be most injurious to a road—a stage-coach, drawn by four horses, weight of coach three tons, horses two tons, breadth of tire two inches and a half; or steam-coach, wheels four inches tire, weight four tons; in both cases velocity ten miles per hour?"—"Taking for granted that the injury which a road sustains by the wheels of carriages and the feet of horses is proportional to the wear of iron on the wheels and on the horses, and that the statement before given as to the actual wear on each be found correct, I would say, the injury done to the road by the steam-carriage weighing four tons with four-inch wheels, would be less than that occasioned by the coach weighing three tons, drawn by four horses."

"Would it be beneficial or otherwise to the roads, that steam-carriages drawing heavy weights in carriages attached to them should be substituted for waggons drawn by horses, supposing that the weight of the drawing or propelling carriage should not in any case exceed the weight of the number of horses that would have been used to draw a corresponding weight, *e. g.*

Waggon - - - -	8 tons	On steam-carriage - -	4 tons
Eight horses, 15 cwt. each	6 ditto	Carriage drawn - -	10 ditto
	14		14?"—

"I am of opinion, that if the steam-carriage and its accompanying carriage be constructed with wheels of a proper width, and of the same diameter as the waggon wheels, and travel with the same velocity, that the injury on well-made solid roads will not be more than that caused by the waggon and horses; in fact, if the proportion of injury before stated be correct, it will be less; but it must be recollected that weak roads suffer more than solid ones from the heavy pressure of wheels, and in such cases the steam-carriage and its tender would be more injurious."

"In descending hills, steam-carriages can regulate their velocity by reducing the action or number of revolutions of the wheels; this acts as a drag, but with the advantage to a road that the wheel moves continually round; which would be most injurious to a road, the descent of a carriage dragged as usual (not omitting the operation of the horses' feet,) or the steam-carriage dragged or regulated in the mode described?"—"Not having seen a steam-carriage descending a hill in the manner described (that is, regulated by the action of the engine on the wheel,) I cannot give a satisfactory answer to this question; but as far as opinion goes, I should say that the joint action of the horses and drag would be more injurious than the steam-carriage, the motion of which was regulated in the above manner, provided the wheels were of the proper width, and the total weight not greater than that of the coach and horses."

"Various local acts having passed, placing excessive tolls on steam-carriages, it may be requisite to introduce a general bill, which shall, on such roads, place steam-carriages on a fair equality (so far as their relative injury or wear of road) to common coaches on each such road; the toll on a coach on such roads may vary from one to two shilings, according to local circumstances; on a waggon in the same proportion; what standard of charge would you suggest for steam-carriages?"—"It has been stated to us, that one steam-carriage has drawn a carriage containing as many as thirty passengers, at the rate of even ten miles per hour, and nine tons weight at the rate of five miles per hour, but with smaller wheels; what regulation would you suggest as to the breadth of tire; or should tolls be chargeable in inverse proportion to the breadth of tire?"—"The toll which carriages propelled by steam, or by any other mechanical means, should be required to pay, ought, in my opinion, to be in proportion to the injury they would do to the roads, compared with that done by the present description of carriages and the horses employed to draw them, without reference to the weight or quantity of goods carried; but as I before stated, I do not believe an accurate estimate can be at present formed as to the injury that roads may sustain from steam-carriages, compared with the injury done to them by coaches drawn by horses; it may, however, I think be safely assumed, that the injury done to a road by a steam-carriage would not be greater than that occasioned by a stage-coach drawn by horses, the weight of the engine and its load being supposed not to weigh more than the stage-coach, together with its load and horses; if this be granted, and an act passed limiting the width of wheel in a certain proportion to the weight carried, there would not be much difficulty in arranging a scale of tolls applicable to steam-carriages, which would put them on an equitable footing with carriages drawn by horses; if, for instance, a proportion, such as I have already mentioned, be adopted, viz., that a wheel should be an inch in width for every 5 cwt. it has to support, and a toll charged for each inch equal to the amount charged for a horse drawing in a carriage which travels with the velocity of the engine, it would, in my opinion, be a fair and equitable toll at least for some years, or until a correct proportion of injury was ascertained by experience and observation, when it might be altered or amended according to circumstances. This mode of charging toll would be extremely simple, and not likely to be misunderstood by toll-collectors, or to occasion any disputes; but there should be a heavy penalty attached to the proprietors of steam-carriages if they put a greater weight on the carriage than the wheels were intended to carry. If the engine, instead of carrying the load, draws one or more carriages after it, the toll should be collected and charged on each carriage, in a similar manner as it is charged on the engine, that is, in proportion to its wheels. An example will illustrate my meaning more clearly; suppose an engine, together with its load, to weigh nine tons (which is about the average weight of two stage-coaches, including the weight of the horses which draw them) to pass through a toll-gate where horses drawing coaches are charged *6d.* each, the toll on the two coaches would be 4*s.*, and of the steam-carriage 4*s.* 6*d.* Suppose that the engine, instead of carrying the load, draws a carriage after it, and that the weight of the engine is five tons, with five-inch wheels, and of the accompanying carriage four tons, with four-inch wheels, the toll of the engine would be 2*s.* 6*d.*, and of the tender 2*s.*, making 4*s.* 6*d.* as before. The only objection I can see to this mode of charging toll on steam-carriages travelling over the turnpike-roads would be, that in the event of their being able to carry a greater number of passengers at a cheaper rate than the present description of carriages drawn by horses, it would lessen the amount of toll collected, as a fewer number of carriages would do the work, and many persons who drive their own horses would travel by them if found cheaper to do so; and this circumstance, although it would not affect the state of repairing in which the road was previously maintained, it might lessen the value of property invested in the different turnpike-trusts throughout the kingdom, which is a very considerable sum; but such a circumstance should not militate against an invention likely to prove beneficial to the country at large."

"Give your opinion on the probable extent of injury to roads from steam-carriages?"—"Generally speaking, I should say that the injury roads will sustain by the introduction of steam-carriages will be much less than is commonly supposed; but the actual amount of injury, or correct estimate of the comparative injury that will be done by a steam-carriage, cannot, in my opinion, be formed at present with any degree of certainty. Experience alone will decide the point. The only danger, in my mind, that is to be apprehended, is the injury which roads may sustain by the possibility of the wheel which is acted upon by the engine turning round without propelling the carriage, in which case the road would suffer considerably; and this would take place, if a train of carriages were attached to the engine, the draught of which was more than the friction or gripe of the engine-wheel on the surface of the road. As long, however, as the weight is carried by the engine, and not drawn after it, nothing of this kind will take place, even on our steepest hills."

"Have you communicated your conclusions on these subjects to Mr. Telford?"—"I have."

"Does he coincide with you?"—"Quite so."

"You stated, that the only probable injury to the roads from the travelling of steam-carriages would be the slipping of wheels; would it not be directly against the interest of the proprietor that the wheels should slip in any degree, there being a necessary loss of power every time they do slip?"—"Clearly so."

"From your observations of the effects produced by heavy carriages drawn by horses, in ascending and descending hills, what would be the effect under similar circumstances of a steam-carriage of a weight equal to the weight of the coach and horses?"—"I am of opinion that the effect or injury to a road would be less by the steam-carriage; for when hills exceed a certain rate of inclination, gravity overcomes the friction of the surface, and the carriages in descending press upon the horses, unless a drag be applied to one of the wheels. This, in itself, injures the road, but not so much as when no drag is used, because the horses are then obliged to bear against the carriage, and set down their feet very strongly; this often tears up the surface, particularly of weak roads. The time that is lost by the coaches in descending some of the hills on the road between London and Birmingham, is full as much as is lost in ascending them, besides the imminent danger, even with the greatest caution on the part of the drivers. If proper springs were used, the draught would be lessened, and of course the injury to the road would be much diminished."

"On every road there are numerous six-horse waggons; you state the weight to be four tons and a half, the horses weighing four and a half more, making nine tons; should any objection be taken to a single steam-carriage of this weight, or from nine to ten tons, provided the wheels be of a proper description?"—"No; I think in the general state of roads, a steam-carriage of from nine to ten tons could run with perfect safety, without injury to the roads, if it was constructed with proper wheels."

"The above question refers to a steam-carriage carrying its load; if the engine-carriage were of the weight of four tons, drawing a second carriage of the weight of six tons, thus dividing the weight over eight wheels, would the effect on the road be less injurious provided it was four and a half tire?"—"I think the injury would be less, provided the engine had the power to propel itself, and draw a carriage with six tons after it, without a slipping of its wheels."

"Carrying this principle further, if the load were divided into two carriages, each to weigh three tons, thus dividing the load over twelve wheels, would not less injury still be done?"—"Decidedly, particularly on weak roads."

"If under these circumstances you can diminish the pressure on the road by multiplying the number of wheels, should not care be taken so to frame the tolls to be levied as not to discourage the use of those steam-carriages, whose greater number of wheels could be least injurious to the roads?"—"I think that would be regulated by the mode I have suggested of charging toll."

"Have you seen Mr. Gurney's carriage, and examined its effects on the roads?"—"I have seen it."

"What state were the roads in, at what velocity was it going, how many persons did it carry, and what was its weight?"—"I do not know the weight of the carriage, there appeared to be eight or ten people on and about it; the road on which I saw it was excessively bad, one of the worst in the country; the velocity was probably five or six miles an hour."

"Were there other loaded carriages passing along the road at the same time?"—"Several; both coaches and waggons."

"Did you remark the effect of the steam-carriage on the road, to see that it did less or greater injury than the other carriages?"—"I could not perceive any difference."

"If there had been any great difference, you would have perceived it?"—"As far as leaving a track behind, which would have been perceived, I could not ascertain the amount of injury; it was nothing more than that done by common coaches."

"Do you think it essential that the wheels of steam-carriages should follow in the same track, provided they have a proper breadth of tire?"—

"Not at all, as regards the injury to the road; it would require more power to work them if the wheels did not follow in the same track."

"Supposing the steam-carriages, either the propelling carriage and the carriage drawn, or the engine-carriage carrying the passengers, were generally to be four tons, what would you recommend to be the minimum breadth of tire to either of the carriages?"—"In the present state of steam-carriages, as applied to the working over turnpike-roads, I should say you might limit them to not less than four inches for a few years."

"Supposing their average weight never exceeded from six to eight tons, do you think four and a half would be a safe minimum?"—"I am inclined to think it would be rather too little."

* * * * * * "The following table will show pretty nearly the increase of expense in transporting goods by stage-coaches drawn by horses up planes of different rates of ascent. Roads in general have, in some parts, steep ascents; one in fifteen between this and Birmingham, for instance, is too much on a road of such traffic. The surfaces are not so good generally as they ought to be; the roads should be strengthened, either with a pitched bottoming of stone, or a concrete mass, such as the Highgate Archway, or the new road near Coventry."

TABLE.

Expense of drawing One Ton over One Mile, at different Rates of Acclivity, by a Stage-Coach and Waggon.

Four-Horse Stage-Coach, average Velocity 10 Miles per Hour.		Waggon, Four Horses, average Velocity 2½ Miles per Hour.	
Rates of Acclivity.	Pence and Decimals.	Rates of Acclivity.	Pence and Decimals.
	d.		d.
1 in 10	77·24	1 in 10	52·07
1 — 15	57·78	1 — 15	28·70
1 — 20	50·47	1 — 20	22·83
1 — 30	44·15	1 — 30	18·55
1 — 40	41·25	1 — 40	16·79
1 — 50	39·56	1 — 50	15·82
1 — 60	38·46	1 — 60	15·20
1 — 70	37·68	1 — 70	14·77
1 — 80	37·09	1 — 80	14·46
1 — 90	36·64	1 — 90	14·22
1 — 100	36·28	1 — 100	14·04
1 — 150	35·19	1 — 150	13·46
1 — 200	34·64	1 — 200	13·18
1 — 300	34·09	1 — 300	12·91
1 — 500	33·65	1 — 500	12·69
1 — 1000	33·32	1 — 1000	12·53
Horizontal.	32·98	Horizontal.	12·36

"What would be the difference of expense of pavement and forming a good granite road in the neighbourhood of London; say twenty miles?"—

"If you take twenty miles, and also take the repairs of the roads for twenty years into accouut, I should say paving would be the cheapest. The great defect of all the London pavements arises from want of a strong and firm foundation. In Fleet Street, and some others, this has been partly accomplished of late, but certainly not as perfect as it might be. If on the road from this to Birmingham there was a portion laid off on the side of the road for steam-carriages, which could be done without difficulty; and if it be made in a solid manner, with pitching and well-broken granite, it would fall very little short of a rail-road. My only reason for keeping it distinct from the other road, is the evident injury every road sustains from horses travelling over it, and breaking up the surface; and the steam-carriages would be able to go with greater velocity, if they were not interrupted with droves of cattle: besides, it would be easy to fence it off from fifteen to twenty feet, without injury to property; and the expense of making a solid road of twelve or fifteen feet would not be very considerable."

"Would the wear of such roads as you have described be much affected by the greater or less velocity of the steam-carriages?"—"It would be hardly affected at all, on a good road, by increased velocity; if any thing, perhaps rather less."

"Do you propose, in your scheme of toll, that weight should be the basis of toll, but that the wheel be an index to the weight?"—"Yes; that is the principle on which I have suggested the scale of tolls."

"How would you check the frauds of proprietors of steam-carriages, by their placing a greater weight in proportion to the breadth of tire?"—"I conceive the use of the steam-carriage would be for passengers solely, and their luggage; if the weight was ascertained in the yards at London, Birmingham, or Shrewsbury, the intermediate traffic would differ very little, for persons going short distances would go by the coaches, as at present."

"Would you suggest that a licence should be granted to steam-carriages, limiting the number of passengers they should take, in proportion to the breadth of tire of the wheel?"—"I think it would be quite as much as the road-trustees could expect; and by marking in large characters the width of wheel on the carriage, it would be a great preventive to the proprietors altering the wheels."

"Do you think, considering the infant state of this invention, that the road-trustees would practically suffer any great injury or inconvenience by merely, for two or three years, placing steam-carriages, whatever weight they may be, on a level with ordinary carriages, with reference to the toll charged for them?"—"Considering the present imperfect state of steam-carriages for turnpike-roads, I think it would do no injury to road-trusts, if such a regulation was adopted."

"Would you place steam-waggons on the same footing as waggons drawn by horses?"—"Yes, provided the wheels are made as I described, in proportion to the weight. There should be the same toll on a waggon drawn by steam as a waggon drawn by horses; that is, the width of wheel should be charged per inch, as the horses are now charged."

"Should a steam-waggon be licensed as to its weight, in the same manner as a steam-coach?"—"I think just the same."

"Did you conduct the experiments made on the Holyhead road, as to the force of traction required on different inclinations?"—"I did."

"Were they carefully made otherwise?"—"They were carefully made, as far as the materials would allow; the waggon was a very large one, with common axletrees. The result, in some cases, differed from two to three pounds: on the whole, I should say, the results stated in that report do not exceed, in any case, five pounds beyond what they would be found, if proved by the best practical instruments, and are confirmed by my subsequent observations and experience. The object we had in view, by these experiments, was to show to the trustees and the surveyors of the roads, that a road might appear a very good one, and still not be one adapted for traffic. By these means, they have perceived the defective parts in the roads; and within three months after the Report of the Parliamentary Commissioners became public, there was not a hedge on that part of the road where the draught was shown to be excessive, that was not cut down, and improvements made on the surface."

"When you followed Mr. Gurney's carriage, did you perceive that any horses were frightened, or any inconvenience arose to passengers on the road?"—"I did not perceive the least inconvenience; I saw several horses pass, both gig and saddle-horses; also coaches, and not one took the least notice of it."

Having, we trust, made it obvious that steam-carriages are able to go up hills, and even *up long* and *steep* hills, we proceed to a comparative view of inland communication by means of steam-carriages on turnpike-roads, and of steam or other power on rail-ways.

A smooth wheel will roll along a smooth plane of iron rail much easier than it will roll along a plane covered with rough and loose stones; for in this last case, it has either to be lifted over the inequalities of the stones, or it has to crush them, or it has to push them to one side whilst it passes. The lifting over a ridge of stones at right angles to the line of motion, need not here be noticed, if these stones are so placed that the wheel runs over the tops, and is not deflected from its course; because, in such case, the gravity of the wheel lifted up one side carries the wheel down on the opposite side, and aids its rise over the next stone: and it is well established by practice, that the inequalities of a rough pavement are not felt at the speed of four miles an hour. But the crushing of the rough material, or the pushing of such rough material to one side, is so much power lost. Hence the great advantage of a smooth road, where this loss of power is avoided or reduced. To obtain this smooth road, it is probable that rails of wood were first resorted to, and then roads of stone or of iron. The two latter have long divided opinions as to their merits. Of late, however, the experiment has been made, at Glasgow, for a satisfactory solution of the question.

If an iron-tram road had been laid down on the Commercial Road, instead of Mr. Walker's granite road there, the iron trams must have been so constructed, that carriages could draw off and on; and many engineers think the cost of the iron-tram road would have been much greater than the granite road. The experiment at Glasgow, just mentioned, showed a very great advantage in the use of iron instead of whin-stone; but as the relative cost of whin-stone and granite (including duration) was tried on the principal street of Aberdeen, and resulted in favour of granite, the comparative merits of an iron tram and a granite tram, remains yet to be decided. Certainly, however, an *edge* rail-way, where practicable, is less expensive than such a granite road.

The substitution of a smooth even road for the wheels to run upon, in place of a rough loose road, is then the reason for adopting a rail-way; " and where applied in proper places and under judicious management, cannot fail of becoming highly beneficial." But nothing can be more delusive than to suppose, that because rail-roads are better (in this respect) than " high-roads, they will answer every where; and yet the existing rage for them would seem to justify such an opinion[1]."

So ardent were rail-road projectors in 1825, that schemes were published, requiring TEN MILLIONS STERLING OF CAPITAL. We cannot enumerate the various lines, but to mention only one, " the Cramford and High Peak Rail-way." " *Not one ton* of all the great commerce announced in the first account has ever passed on it for the whole distance, and no carriage whatever except that which conveyed the committee, on their triumphant tour at its opening; all the trade having been confined to that of a little coal at the southern end[2]."

It will be found that, with the exception of the Liverpool and Manchester line, and of those lines formed solely for the purpose of conveying heavy materials on a descending road, railways are, at least, of very questionable advantage when there is the possibility of having a good turnpike-road and steam-carriages.

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[1] Report on Rail-roads by Mr. Charles Silvester, Civil Engineer.

[2] Letter to a Friend on Rail-ways and Canals; published by Longman & Co.

The splendid rail-road between Manchester and Liverpool has led many to propose laying the slow canal barge aside, draining the canals of their water, and forming a rail-way on the level bottom, erecting stationary steam-engines at all inclined planes where the canal locks now are; but canal property is not so easily proved inferior. Mr. Wood has given the most favourable view of rail-roads, and attempted to prove the impracticability of competition between canals with horses, and rail-roads with locomotive engines, in the conveyance of passengers. But Mr. Grahame, in his Letter to Mr. Wood, most clearly shows the latter gentleman to be in error. We consider the case so clearly made out by Mr. Grahame against rail-roads, that we can only refer those who require information to his Letter[1]: a letter well worthy the serious consideration of all who have interest in lines of rail-road, where canals already exist.

The competition has been said by Mr. Wood "to rest almost wholly betwixt rail-roads and canals." And now we return to our subject to show that rail-roads have a very formidable rival in steam communication upon the common road, and that the latter is of vastly greater advantage than the former. I do believe that had Mr. Wood turned his persevering energies and usual discrimination to bear upon the subject of turnpike-roads, such a line would not have appeared in his work.

What moving power should be used, or rather, in what way that power should be applied to give the greatest advantage on a rail-road, seems to be a question still to be discussed. Messrs. Walker and Rastrick, after much investigation, reported to the directors of the Liverpool and Manchester rail-way, that stationary engines were the best. That Company, however, adopted locomotive-engines, and now the directors think of abandoning them, and adopting either stationary engines or horses. It forms, therefore, a very interesting question, what can be the cause of this?

After reading Mr. Crawshay's letter, quoted in the last chapter, and the evidence above adduced, as to the wear of other locomotive-carriages, we must conclude that such carriages could not cost 1500*l.* per ann. each, as we are well informed the repair of those on the Liverpool and Manchester line amounts to. It is quite possible that this sum may be exaggerated, but a fact corroborates its truth. Last summer that company had *seventeen* locomotive engines, only *five* of which were fit for work, and the company had to borrow one from the Bolton railway; at present (and in general) that company have only *six* of their locomotive-engines fit for use: the rest of the *twenty-four* are under repair! Much of this expense must be accounted for, by the wearing out of Messrs. Stevensons and Co's. boilers, and by the too great speed of the alternating piston. But the rise of 1 foot in 96 feet, on the Whiston and Sutton inclined planes, put that company to great additional expense.

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[1] Letter to Nicholas Wood, Esq. by Thomas Grahame, Esq.; published by Smith and Son, Glasgow; and Longman, London.

These ascents are so gradual that travellers think them dead level. Here we have the finest exhibition of a rail-road and locomotive-power upon it. What is the cause of the expense on the inclined plane? It is the disadvantage which must ever attach to locomotive-engines working up an inclined *rail*, and which does not in the same measure attach to a steam-carriage working up an inclined turnpike-road. We have said above, that the whole and sole advantage of an unyielding rail-road consists in the substitution of a smooth rail for a rough yielding road; and wherever there is a dead level, a rail-way offers a very great saving of power; but wherever there is an inclination to ascend, that *advantage decreases* in an enormous ratio. I will quote Mr. Gurney's observations on this head, which[1] (although his case supposed is an extreme one) are original, and place the subject in a true and clear light.

" As it would appear that some persons are still of opinion, that locomotive-engines cannot propel themselves up hill on the common road, I would call their attention to the following circumstances.

" 1st. The amount of extra power necessary to draw a certain weight up a hill is given by the inclination, and is the same whether it be on a rail-road or common road, whether it be carried on a horse's back, or dragged on wheels, or on a sledge. This increment is occasioned by *gravitation* alone.

" 2nd. The *force* of traction necessary to propel a ton weight on a level rail-road is about 8 lbs.; that is $\frac{1}{280}$th; or to be within limits in practice, say $\frac{1}{240}$th part of the whole weight. The *average* force required to draw a ton weight on a common road, is the $\frac{1}{12}$th of the whole weight. The former is, therefore, to the latter as 1 to 20.

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[1] Mr. Goldsworthy Gurney's observations on steam-carriages on turnpike-roads.

"3rd. To go up a hill rising one foot in twelve, viz. three inches in a yard, which is about the steepest now on our public roads, an additional force of traction is required equal to $\frac{1}{12}$ the weight, to overcome the increased opposition arising from gravitation. Thus, then, to go up a common road of the above elevation, the power of traction is simply doubled, and no more, while on a rail-road, it is increased to $\frac{1}{12}+\frac{1}{240}=\frac{21}{240}$, or 21 times greater than it was on the level.

"It is this enormous difference in the tractive force necessary to propel a given weight up an inclined plane on a rail-road, which is so sensibly felt in the slightest elevations, and renders the ascent of the heavy engines impossible against one of moderate rise, particularly with any load attached to them. It is this circumstance which deceives our scientific men, when they carry their speculations into the subject of steam-carriages on common roads.

"It is evident from this, that if a steam-carriage has only double the power wanted on a level common road, it can ascend any hill that we have; but to ascend the same elevation on a rail-way, the engine must exert a power no less than *twenty-one times* that it required on a level."

Mr. Silvester, in a report to the directors of the Liverpool and Manchester rail-road, in 1824, almost shows it,—by going a few words farther the truth would have appeared; but in his calculations, comparing the travelling of a locomotive-engine and train on a plane, and *down* an inclination assisted by its *gravitating force*, he scarcely notices the additional power required to travel the same *up* an inclination against the gravitating force. If the gravitating force of the gross weight towards the earth's centre, increases the facilities of descent, according to the well-known laws of gravitation, so also must the gravitating force operate *against the ascent.* In which latter case all the advantage we had from a smooth rail vanishes into nothing; even supposing the locomotive-engine could propel itself up a rail inclined to the horizon 1 inch in every 12, which is impossible.

It is well known that to move any body up hill, is to lift it up the height of the line which joins the extreme end of the hill with the base, and at right angles to the base. Hence a body to be moved up a rise of 1 foot in 12 feet has, in fact, to be lifted one foot. The movement could either be effected by rolling it up the inclined plane (the hypotenuse of the right angle triangle), or by rolling it along the plane, and then lifting it up the one perpendicular foot of rise; these two last lines being the base and perpendicular of this right-angle triangle.

The long train of waggons can easily be rolled along the *plane*. There the saving, when compared with a turnpike-road, is admitted to be so great as $\frac{19}{20}$ths, or the traction on a *level* rail-road is to the traction on a level turnpike-road as 1 is to 20; but when the train on the rail-way comes to ascend, the *advantage* of a rail-way is lost. Mr. Wood states, that if a locomotive-engine draws, by the adhesion of its four wheels, 67·25 tons on a level, it will only draw, by the same adhesion, 15·21 tons up an inclination of one in one hundred; and he gives data for calculating that a rail-road locomotive-engine, working by the adhesion of the wheels on the rail, will not ascend an inclination greater than one foot in twenty feet, or, perhaps, one in fifteen. Its power of doing any useful work, on such an inclination, has vanished.

Now we have seen, both from Mr. Stone's evidence and letter, and from Sir Charles Dance's confirmation of them, above quoted, that one of Mr. Gurney's engines drew eleven tons (including the weight of the carriage) up an ascent of one in twenty; and if we examine this by calculation, we shall find it must be so; for 24640 lbs. on a *level turnpike-road*, requires (it is well known) a power of traction of 2053 lbs. On a rise of one in one hundred, we must add to the power of traction $\frac{1}{100}$th of the weight $= \frac{24640}{100} = 246\frac{1}{2}$ lbs. Hence we have the weight, 24640 lbs. drawn up one in 100, by 2053 lbs. + $246\frac{1}{2}$ lbs. = $2299\frac{1}{2}$ lbs. On a rise of one in fifty, we must add $\frac{24640}{50}$ to the force of traction required on the level. Thus, 24640 will be drawn up one in fifty, by $\frac{24640}{50} + 2053 = 2545$ lbs. So that a small increment of power (by steam) will even carry the weight up one in twenty—the ascent mounted by Mr. Gurney's engine.

Now let us construct a comparative table upon this mode of calculating a steam-carriage's performance on turnpike-roads, and place, in juxta-position, an account of locomotive-engine performance on the rail-way, as calculated from Mr. Wood's data, above mentioned.

TURNPIKE-ROAD.			RAIL-ROAD, calculated from Mr. Wood's data.		
Upon	Gross Weight.	Power required	Upon	Weight.	Power required.
	lbs.	lbs.		Tons.	
a level	24640	2053	a level	67·25	Power required not given.
1 in 100	24640	2299½	1 in 100	15·21	Same power.
1 — 50	24640	2545	1 — 50	Not given, but almost 0 . .	Same power.
1 — 20	24640	3285			
1 — 12	24640	4106	1 — 12	Locomotive engine will not ascend by itself on a rail-way.	

This is sufficient reason for saying, that the *advantage* of a rail-way is almost confined to a dead level; or, that a very trifling ascent reduces the advantage so much, that capital cannot be profitably invested in a rail-road, for general purposes, of such inclination. The extent of capital required for the Liverpool and Manchester rail-road, (nearly 900,000*l.*) which is most advantageously situated, whether we consider the level country or the numerous travellers and goods passing along the line, is a great argument against general rail-ways. Nay, upon looking at the above table, we venture to predict that a well-regulated steam-carriage conveyance upon the turnpike-road betwixt Manchester and Liverpool, would beat the far-famed "Planet" in its orbit—we question if it could travel *far* out of its orbit. Certainly passengers could thus be carried for less money: and the owners be amply remunerated!

We come now to consider a material advantage in the application of the power of a steam-carriage over the application of horse-power. When a horse moves forward, the centre of gravity of his body and of his whole frame, describes a continued series of curves making an indented line. This motion will be best seen, when we look from one side of a high wall at the head of a man on horseback, upon the other side of the wall. The rider's head will be more or less seen as the horse moves, even in a walk. If the horse trots, the curvilinear motion will be still more obvious. The horse moves in a series of curves, his feet being the centres. When he walks he leans forward, and as he falls forward, advances his feet to support himself. When he has to draw a heavy carriage, he is obliged to go slowly, at a walk, and the alternate rising and falling of his body when he does so, communicates to the carriage a succession of tugs. This is easily felt in a gig, either when the horse walks or trots, and it is always discernible in going up a steep hill with one horse. When the carriage has four horses the tugs cannot be so distinctly felt, but still they are perceptible; therefore, the horse working by a succession of impulses, has the *vis inertiæ* to overcome at every step. This, the steam-carriage, driving by the wheel, has not to do; having one cylinder always in full force, the carriage has a *continuous roll onward,* and the *vis inertiæ* requires not to be overcome, except when the carriage is at first started.

A great deal of the horse's power, in drawing a carriage, is obtained by his leaning forward. When leaning forward, he puts out his feet to support himself; and this movement of the feet we cannot calculate, as it is involved in a physiological law, known only to our Omnipotent Maker. But we do see that every animal moves with great ease on a level, whilst moving up an inclination is distinctly seen as distressing. It is this which makes a hilly road so oppressive to an aged person. His muscular power is easily and imperceptibly put forth on a level; but when he comes to a hill, the power required to lift his body is very distinctly seen to oppress him. A horse has the same facility in moving on the plain, and the same difficulty in moving himself up a hill; and the *animal's* power required to move himself up a hill, is to the *animal's* power required to move himself on the level, in a much greater ratio than the ascent is to the level: whilst with *elemental power they are in the same proportion to each other.* So we arrive at the conclusion, that hilly roads are actually less objectionable for steam-carriages than for horses.

CHAPTER V.

UPON THE WAYS AND MEANS.

WE have now, in a cursory manner, considered the important advantages which will result to society from the substitution of inanimate for animate power for locomotive purposes; the process by which elemental power is obtained; the application of that power to locomotive machines; and the roads adapted for them. In conclusion, we have only to embody, as confirmatory of every thing we have advanced upon the subject generally, the Report of the Select Committee, and afterwards to follow it up by a few observations upon the ways and means by which the substitution in question may be brought about. The Report meets so directly and substantially every objection affecting the utility and practicability of the project, that the *modus operandi* is the only topic particularly requiring discussion, which is left behind.

"The SELECT COMMITTEE appointed to inquire into, and to report upon, the proportion of tolls which ought to be imposed upon coaches and other vehicles propelled by STEAM or GAS, upon turnpike-roads; and also, to inquire into, and to report upon, the rate of toll actually levied upon such coaches or other vehicles under any Acts of Parliament now in force; and who were instructed to inquire generally into the present state and future prospects of land-carriage by means of wheeled vehicles propelled by STEAM or GAS on common roads; and to report upon the probable utility which the public may derive therefrom; and who were empowered to report the Minutes of the Evidence taken before them, to the House:—have examined the matters referred to them, and agreed to the following REPORT.

"The Committee proceeded in the first instance to inquire how far the science of propelling carriages on common roads, by means of steam or mechanical power, had been carried into practical operation; and whether the result of the experiments already made had been sufficiently favourable to justify their recommending to the House that protection should be extended to this mode of conveyance, should the tolls imposed on steam-carriages, by local Acts of Parliament, be found prohibitory or excessive.

" In the progress of their inquiry, they have extended their examination to the following points, on which the chief objections to this application of steam have been founded; viz. the insecurity of carriages so propelled, from the chance of explosion of the boiler, and the annoyance caused to travellers on public roads, by the peculiar noise of the machinery, and by the escape of smoke and waste steam, which were supposed to be inseparable accompaniments.

" It being also in charge to the Committee, 'to report upon the proportion of tolls which should be imposed upon steam-carriages,' they have examined several proprietors of those already in use, as to the effect produced on the surface of roads by the action of the propelling wheels.

" As this was too important a branch of their inquiry to rest entirely on the evidence of individuals, whose personal interest might have biassed their opinions, the Committee also examined several very scientific engineers, by whose observations on the causes of the ordinary wear of roads, they have been greatly assisted.

" The Committee were directed also to report 'on the probable utility which the public may derive from the use of steam-carriages.' On this point they have examined a member of the Committee, well known for his intelligence and research on subjects connected with the interests of society, and they feel that they cannot fulfil this part of their instructions better than by merely referring the House to the evidence of Colonel Torrens.

" These inquiries have led the Committee to believe that the substitution of inanimate for animal power, in draught on common roads, is one of the most important improvements in the means of internal communication ever introduced. Its practicability they consider to have been fully established; its general adoption will take place more or less rapidly, in proportion as the attention of scientific men shall be drawn by public encouragement to further improvement.

"Many circumstances, however, must retard the general introduction of steam as a substitute for horse-power on roads. One very formidable obstacle will arise from the prejudices which always beset a new invention, especially one which will at first appear detrimental to the interests of so many individuals. This difficulty can only be surmounted by a long course of successful, though probably unprofitable, experiment. The great expense of the engines must retard the progress of such experiments. The projectors will, for a long period, work with caution, fearing not only the expense incurred by failure, but also that too sudden an exposure of their success would attract the attention of rivals. It is difficult to exemplify to the House how small and apparently unimportant an adaptation of the parts of the machinery, or of the mode of generating or applying the steam, may be the cause of the most rapid success; yet he who by a long course of experiment shall have first reached this point, may be unable to conceal the improvement, and others will at once reap the benefit of it.

"The Committee are convinced, that the real merits of this invention are such, that it may be safely left to contend with these and similar difficulties; there are others, however, from which the Legislature can alone relieve it. Tolls, to an amount which would utterly prohibit the introduction of steam-carriages, have been imposed on some roads; on others, the trustees have adopted modes of apportioning the charge which would be found, if not absolutely prohibitory, at least to place such carriages in a very unfair position as compared with ordinary coaches.

"Two causes may be assigned for the imposition of such excessive tolls upon steam-carriages. The first, a determination on the part of the trustees, to obstruct, as much as possible, the use of steam, as a propelling power; the second, and probably the more frequent, has been a misapprehension of their weight and effect on roads. Either cause appears to the Committee a sufficient justification for their recommending to the House, that legislative protection should be extended to steam-carriages, with the least possible delay.

"It appears from the evidence, that the first extensive trial of steam as an agent in draught on common roads, was that by Mr. Gurney, in 1829, who travelled from London to Bath and back, in his steam-carriage. He states, that although a part of the machinery which brings both the propelling-wheels into action, when the full power of the engine is required, was broken at the onset, yet that on his return he performed the last eighty-four miles, from Melksham to Cranford Bridge, in ten hours, including stoppages. Mr. Gurney has given to the Committee very full details of the form and power of his engine, which will be found in the evidence.

"The Committee have also examined Messrs. Summers and Ogle, Mr. Hancock, and Mr. Stone, whose steam-carriages have been in daily use for some months past on common roads. It is very satisfactory to find that although the boilers of the several engines described vary most materially in form, yet that each has been found fully to answer the expectation of its inventor. So well, in fact, have their experiments succeeded, that in each case where the proprietors have ceased to use them, it has only been for the purpose of constructing more perfect carriages, in order to engage more extensively in the business.

"When we consider that these trials have been made under the most unfavourable circumstances,—at great expense,—in total uncertainty,—without any of those guides which experience has given to other branches of engineering;—that those engaged in making them are persons looking solely to their own interest, and not theorists, attempting the perfection of ingenious models;—when we find them convinced, after long experience, that they are introducing such a mode of conveyance as shall tempt the public, by its superior advantages, from the use of the admirable lines of coaches which have been generally established;—it surely cannot be contended, that the introduction of steam-carriages on common roads is, as yet, an uncertain experiment, unworthy of legislative attention.

"Besides the carriages already described, Mr. Gurney has been informed, that from 'twenty to forty others are being built by different persons, all of which have been occasioned by his decided journey in 1829.'"

"The Committee have great pleasure in drawing the attention of the House to the evidence of Mr. Farey. His opinions are the more valuable, from his uniting, in so great a degree, scientific knowledge to a practical acquaintance with the subject under consideration. He states, that he has 'no doubt whatever but that a steady perseverance in such trials will lead to the general adoption of steam-carriages:' and again, 'that what has been done proves to his satisfaction the practicability of impelling stage-coaches (by steam) on good common roads, in tolerably level parts of the country, without horses, at a speed of eight or ten miles per hour.'

"Much, of course, must remain to be done in improving their efficiency; yet Mr. Gurney states, that he has kept up steadily the rate of twelve miles per hour; that 'the extreme rate at which he has run is between twenty and thirty miles per hour.'

"Mr. Hancock 'reckons, that with his carriage he could keep up a speed of ten miles per hour, without injury to the machine.'

"Mr. Ogle states, 'That his experimental carriage went from London to Southampton, in some places, at a velocity of from thirty-two to thirty-five miles per hour.'

"'That they have ascended a hill rising one in six, at sixteen and a half miles per hour, and four miles of the London road, at the rate of twenty-four miles and a half per hour, loaded with people.'

"'That his engine is capable of carrying three tons weight, in addition to its own.'

"Mr. Summers adds, 'That they have travelled in the carriage at the rate of fifteen miles per hour, with nineteen persons on the carriage, up a hill one in twelve.'

"'That he has continued for four hours and a half to travel at the rate of thirty miles per hour.'

"'That he has found no difficulty of travelling over the worst and most hilly roads.'

"Mr. James Stones states, that 'thirty-six persons have been carried on one steam-carriage.'

"'That the engine drew five times its own weight nearly, at the rate of from five to six miles per hour, partly up an inclination.'

"The several witnesses have estimated the probable saving of expense to the public, from the substitution of steam-power for that of horses, at from one-half to two-thirds. Mr. Farey gives as his opinion, 'That steam-coaches will very soon, after their first establishment, be run for one-third of the cost of the present stage-coaches.'

"Perhaps one of the principal advantages resulting from the use of steam will be, that it may be employed as cheaply at a quick as at a slow rate; 'this is one of the advantages over horse labour which becomes more and more expensive, as the speed is increased. There is every reason to expect, that in the end the rate of travelling by steam will be much quicker than the utmost speed of travelling by horses; in short, the safety to travellers will become the limit to speed.' In horse draught the opposite result takes place; 'in all cases horses lose power of draught in a much greater proportion than they gain speed, and hence the work they do becomes more expensive as they go quicker.' On this, and other points referred to in the report, the Committee have great pleasure in drawing the attention of the House to the valuable evidence of Mr. Davies Gilbert.

"Without increase of cost, then, we shall obtain a power which will insure a rapidity of internal communication far beyond the utmost speed of horses in draught; and although the performance of these carriages may not have hitherto attained this point, when once it has been established, that at equal speed we can use steam more cheaply in draught than horses, we may fairly anticipate that every day's increased experience in the management of the engines will induce greater skill, greater confidence, and greater speed.

"The cheapness of the conveyance will probably be for some time a secondary consideration. If at present it can be used as cheaply as horse-power, the competition with the former modes of conveyance will first take place as to speed. When once the superiority of steam-carriages shall have been fully established, competition will induce economy in the cost of working them. The evidence, however, of Mr. M'Neil, showing the greater efficiency with diminished expenditure of fuel by locomotive-engines on rail-ways, convinces the Committee, that experience will soon teach a better construction of the engines, and a less costly mode of generating the requisite supply of steam.

"Nor are the advantages of steam-power confined to the greater velocity attained, or to its greater cheapness than horse draught. In the latter, danger is increased, in as large a proportion as expense, by greater speed. In steam power, on the contrary, 'there is no danger of being run away with, and that of being overturned is greatly diminished. It is difficult to control four such horses as can draw a heavy carriage ten miles per hour, in case they are frightened, or choose to run away; and for quick travelling they must be kept in that state of courage, that they are always inclined for running away, particularly down hills and at sharp turns of the road. In steam, however, there is little corresponding danger, being perfectly controllable, and capable of exerting its power in reverse in going down hills.' Every witness examined has given the fullest and most satisfactory evidence of the perfect control which the conductor has over the movement of the carriage. With the slightest exertion it can be stopped or turned, under circumstances where horses would be totally unmanageable.

"The Committee have throughout their examinations been most anxious to ascertain whether the apprehension, very commonly entertained, that an extensive use of these carriages on roads would be the cause of frequent accidents and continued annoyance to the public, were well founded.

"The danger arising from the use of steam-carriages was stated to be two-fold;—that to which passengers are exposed from explosion of the boiler, and the breaking of the machinery, and the effect produced on horses, by the noise and appearance of the engine."

"Steam has been applied as a power in draught in two ways; in the one, both passengers and engine are placed on the same carriage; in the other, the engine carriage is merely used to draw the carriage in which the load is conveyed. In either case, the probability of danger from explosion has been rendered infinitely small, from the judicious construction of boiler which has been adopted.

"These boilers expose a very considerable surface to the fire, and steam is generated with the greatest rapidity. From their peculiar form, the requisite supply of steam depends on its continued and rapid formation; no large and dangerous quantity can at any time be collected. Should the safety-valve be stopped, and the supply of steam be kept up in greater abundance than the engines require, explosion may take place, but the danger would be comparatively trifling, from the small quantity of steam which could act on any one portion of the boilers. As an engine invented by Mr. Trevithick has not been as yet applied to carriages, the Committee can do no more than draw the attention of the House to the ingenuity of its contrivance. Should it in practice be found to answer his expectation, it will remove entirely all danger from explosion.

In each of the carriages describd to the Committee, the boilers have been proved to a considerably greater pressure than they can ever have to sustain.

" Mr. Farey considers that ' the danger of explosion is less than the danger attendant on the use of horses in draught; that the danger in these boilers is less than in those employed on the rail-way, although there even the instances of explosion have been very rare.' The danger arising to passengers from the breaking of the machinery needs scarcely to be taken into consideration; it is a mere question of delay, and can scarcely exceed in frequency the casualties which may occur with horses.

" It has been frequently urged against these carriages, that, wherever they shall be introduced, they must effectually prevent all other travelling on the road, as no horse will bear quietly the noise and smoke of the engine.

"The Committee believe that these statements are unfounded. Whatever noise may be complained of, arises from the present defective construction of the machinery, and will be corrected as the makers of such carriages gain greater experience. Admitting even that the present engines do work with some noise, the effect on horses has been greatly exaggerated. All the witnesses accustomed to travel in these carriages, even on the crowded roads adjacent to the Metropolis, have stated, that horses are very seldom frightened in passing. Mr. Farey and Mr. M'Neil have given even more favourable evidence, in respect to the little annoyance they create.

" No smoke need arise from such engines. Coke is usually burned in locomotive engines on railways to obviate this annoyance; and those steam-carriages which have been hitherto established also burn it. Their liability to be indicted as nuisances will sufficiently check their using any offensive fuel.

" There is no reason to fear that waste steam will cause much annoyance. In Mr. Hancock's engine, it passes into the fire; and in other locomotive engines it is used in aid of the power, by creating a quicker draught, and more rapid combustion of the fuel. In Mr. Trevithick's engine it will be returned into the boiler.

" The Committee, not having received evidence that gas has been practically employed in propelling carriages on common roads, have not considered it expedient to inquire as to the progress made by several very scientific persons, who are engaged in making experiments on gases, with the view of procuring a still cheaper and more efficient power than steam.

"The Committee having satisfied themselves that steam has been successfully adopted as a substitute for horse-power on roads, proceeded to examine whether tolls have been imposed on carriages thus propelled, so excessive as to require legislative interference; and also to consider the rate of tolls by which steam-carriages should be brought to contribute, in fair proportion with other carriages, to the maintenance of the roads on which they may be used.

"They have annexed a list of those local Acts in which tolls have been placed on steam, or mechanically-propelled carriages.

"Mr. Gurney has given the following specimens of the oppressive rates of tolls adopted in several of these Acts. On the Liverpool and Prescot road, Mr. Gurney's carriage would be charged 2*l.* 8*s.*, while a loaded stage-coach would pay only 4*s.* On the Bathgate road, the same carriage would be charged 1*l.* 7*s.* 1*d.*, while a coach drawn by four horses would pay 5*s.* On the Ashburnham and Totness road, Mr. Gurney would have to pay 2*l.*, while a coach drawn by four horses would be charged only 3*s.* On the Teignmouth and Dawlish roads, the proportion is 12*s.* to 2*s.*

"Such exorbitant tolls on steam-carriages can only be justified on the following grounds:—

"First, because the number of passengers conveyed on, or by, a steam-carriage, will be so great as to diminish (at least to the extent of the difference of the rate of toll) the total number of carriages used on the road; or, secondly, because steam-carriages induce additional expense in the repairs of the road.

"The Committee see no reason to suppose that, for the present, the substitution of steam-carriages, conveying a greater number of persons than common coaches, will take place to any very material extent: and as to the second cause of increased charge, the trustees, in framing their tolls, have probably not minutely calculated the amount of injury to roads likely to arise from them.

"The Committee are of opinion, that the only ground on which a fair claim to toll can be made, on any public road, is to raise a fund, which, with the strictest economy, shall be just sufficient, first, to repay the expense of its original formation; secondly, to maintain it in good and sufficient repair.

"Although the Committee anticipate that the time is not far distant when, in framing a scheme of toll for steam-carriages, their general adoption, and the great number of passengers which will be conveyed on a small number of vehicles, will render it necessary, not only to consider the amount of injury actually done to the road, but also the amount of debt which may have been incurred for its formation or maintenance; yet at present they feel justified, by the limited number of such carriages, and by the great difficulties they will have to encounter, in recommending to the House, that, in adopting a system of toll, the proportion of 'wear and tear' of roads by steam, as compared with other carriages, should alone be taken into consideration.

"Unless an experiment were instituted on two roads, the one reserved solely for the use of steam-coaches, the other for carriages drawn by horses, for the purpose of ascertaining accurately the relative wear of each, it would be quite impossible to fix, with certainty, the proportion of tolls to which, on the same road, each class of vehicles should be liable. To approximate, however, as nearly as possible to the standard of relative wear, the Committee have compared the weights of steam-carriages with those of loaded vans and stage-coaches. They have tried to ascertain the causes of the wear of roads; also the proportion of injury done by the feet of horses, and the wheels of coaches; how far that injury is increased by increased velocity; and also in what degree the wear of roads by loaded carriages may be decreased by any particular form of wheel.

"The Committee would direct the attention of the House especially to the evidence of Mr. M'Neil, whose observations on this branch of the subject, being founded on a long course of very accurate experiments, are peculiarly interesting and useful. He estimates that the feet of horses, drawing a fast-coach, are more injurious to the road than the wheels, in the proportion of three to one, nearly; that this proportion will increase with the velocity; that by increasing the breadth of the tires of the wheels, the injury done to roads by great weights may be counteracted. He considers, that on a good road, one ton may be safely carried on each inch of width of tire of the wheels.

"Mr. M'Adam and Mr. Telford have given corresponding evidence, as to the greater wear caused by horses' feet than by wheels of carriages.

"Each of the above witnesses agrees, that, adding the weight of the horses to that of the coach, and comparing the injury done to a road by a steam-carriage of a weight equal to that of the coach and horses (the wheels being of a proper width of tire), the deterioration of the road will be much less by the steam-carriage than by the coach and horses.

"As to the injury to roads, which is anticipated from the 'slipping' of the wheels, it may safely be left to the proprietors to correct: the action of the wheel slipping, involves a waste of power, and an useless expenditure of fuel, which, for their own sakes, they will avoid.

"Apprehension has also been entertained, that although the peculiar action of the wheels may not be injurious, yet that, from the great power which may be applied, if the steam were worked at very high pressure, or if the size of the engine were increased, greater weight might be carried than the strength of the road could bear.

"Undoubtedly, in proportion to the advance of the science, will be the increase of weight drawn by an engine with a given expenditure of fuel; but there are many practical difficulties to be surmounted, before the weight so drawn can reach the point when it would be destructive of roads. There are no theoretical reasons against the extension of the size of the engines. The difficulties, according to Mr. Gurney, are of a practical nature, and only in the 'difficulty of management of a large engine.' In proportion as we augment the power of the engines, we must increase their strength, and consequently their weight; the greater weight will be a material diminution of their efficiency. To a certain extent, the power may be increased in a greater ratio than the weight; but, with our limited knowledge of the application of steam, and with the present formation of the public roads, the point will be very soon attained, when the advantage of increased power will be counterbalanced by the difficulties attendant on the increased weight of the engines.

"The weight of the steam-carriages at present in use varies from 53 to 80 cwt.; but it must be recollected that they are mere models; they were made with attention to strength only, to bear the uncertain strain to which they would be exposed in the course of experiments, and a very considerable diminution of weight may be anticipated.

"The weight drawn, at the rate of ten miles per hour, by Mr. Gurney's engine, has not, on any extent of road, exceeded the weight of the drawing-carriage; nor is it likely, with the difficulties to be encountered on the present lines of road, from their quality and the numerous ascents, that the weight drawn will be in excess of the strength of the roads. The immense quantity of spare power required to surmount the different degrees of resistance likely to occur, would render the engine too unmanageable. This will appear evident from the force of traction required to draw a waggon over the Holyhead and Shrewsbury road, which varied from 40 to upwards of 300 lbs.

"In considering the effect on roads, we must not overlook one peculiarity, in which they have a great advantage over other carriages. In coaches drawn by horses, the power being without the machine to be moved, it becomes an object of the greatest importance to give as much effect as possible to the power, by diminishing the resistance arising from the friction of the wheels upon the surface of the road. For this purpose, the proprietors of coaches and waggons have adopted every possible contrivance, so to reduce the tires of their wheels, that a very small portion of them may press on the road; in some coaches they are made circular in their cross section, so that the entire weight of the carriage presses on a mere point; should the materials be soft, such wheels cut their way into the road like a sharp instrument. The owners of waggons too have adopted a similar plan. Mr. M'Neil states, that the actual bearing part of the tire of apparently broad-wheel waggons, is reduced to three inches, by the contrivance of one band of the tire projecting beyond the others.

"With steam, on the contrary, a certain amount of adhesion to the roads is required to give effect to the action of the machinery, or the wheels would slip round, and make no progress. It appears of little importance, therefore, so far as relates to the engine, whether the requisite amount of friction be spread over a broad surface of tire, or be concentrated to a small point; but as the wheels, by being too narrow, would have a tendency to bury themselves in every soft or newly-made road, and thus raise a perpetual resistance to their own progress, it actually becomes an advantage to adopt that form, which is least injurious to the road. The proprietors who have been examined on this point, seem to be quite indifferent as to the breadth of tire they may be required to use.

"These considerations have convinced the Committee, that the tolls enforced on steam-carriages have, in general, far exceeded the rate which their injuriousness to roads, in comparison with other carriages, would warrant; they have found, however, considerable difficulty in framing a scale of tolls applicable to all roads, in lieu of those authorized by several local Acts.

"With this view, they have carefully examined the various modes of imposing toll, either suggested by the witnesses, or already adopted.

"They are as follow:—

"1. To place a toll proportioned to the weight of the carriage and load;
"2. On the number of passengers;
"3. On the horse-power of the engine;
"4. On the number of wheels;
"5. An unvarying toll.

"Each of these plans seems liable to serious objections, which the Committee beg to submit to the House.

"No plan of toll has been more frequently recommended than that of a charge in proportion to the weight of the engine and load. As this is the most plausible, and (if it could be levied without other disadvantages) would probably be the fairest standard, the Committee have considered it right to state, at some length, their reasons for not recommending its adoption.

"If weight be taken as the standard, the toll must be a fixed charge, either upon the weight of the engine and carriage, without reference to the load; or, upon an estimated average of the load carried; or, a fluctuating charge, according to the weight at the several periods of a journey.

"The first would be at least free from the uncertainty of the other two, and therefore would be preferable; but what scale of charge per cwt. could the Committee recommend as applicable to all roads? Their toll should vary according to every different rate of charge on carriages; besides, it would appear to the trustees very unjust to exclude the consideration of that which would be deemed the most material cause of the wear of their roads; viz. the load.

"A fluctuating charge on weight would be most injurious to a carriage, which will mainly depend for success on its speed; constant altercations would take place between the toll-collectors and proprietors; a minute calculation would be required at every turnpike-gate; in fact, unless an accountant were placed at each, the Committee cannot conceive how the proportions could be satisfactorily arranged; nor would there be any desire, on the part of the toll-collector, to shorten the delay occasioned by these interruptions.

"Mr. Gurney has delivered in a scale of tolls, graduated according to weight and width of tire of the wheel. As this has been drawn up by a person interested in the success of steam-carriages, it might have been expected to be more favourable to them. The Committee, however, have not adopted it, because of the difficulties and interruptions, which a fluctuating rate of toll would induce; besides, this scale purports to be intended for a road, where 3*d.* is charged for a horse drawing, and 1*d.* for a horse not drawing; the scale would be inapplicable, therefore, when the charge was 2*d.* and 1*d.*, 3*d.* and 1½*d.*, 4*d.* and 1*d.*, 4*d.* and 1½*d.*, 8*d.* and so on. Again, what standard of weight, in relation to horse coaches, could be adopted? The average weight of loaded coaches differs very much on different roads. It has been suggested, that a loaded coach, including the weight of four horses, would weigh on an average four tons; and that if 6*d.* per horse were chargeable to the coach, 6*d.* per ton should be placed on a steam-carriage; this would be unjust, as vans, which frequently weigh upwards of six tons, would only pay 2*s.*, and a steam-carriage would pay 3*s.* Even if the injury done to the road by each were equal, this would be an unfair toll; but it will appear more evidently unjust if the greater proportionate injury done by the feet of horses drawing, than by the propelling wheels, be taken into consideration.

"The object of every steam-coach proprietor will be to attain the greatest possible lightness of machinery and engine; because thereby he renders his power more efficient for the draught of the remunerating load. To place the toll on the weight of the engine would tend to induce him to decrease the strength of his boiler and machinery to an extent which might be dangerous to the passengers, and very detrimental to the success of steam-travelling, as the public will easily be led to believe, that accidents really occurring from injudicious legislation, were inseparable from the adoption of this power as an agent in propelling carriages.

"The only fair plea for charging tolls on such carriages, in proportion to their weight, is to prevent a load being propelled or carried which would permanently injure the road; within this limit it would be as injudicious to interfere with their progressive efficiency, (which can only result from improvements of the machinery and the system of generating and applying steam) as it would be to tax carriages drawn by large and well-bred horses, more heavily than such as were drawn by horses in worse condition and of smaller size and power.

"The roads at present have to sustain waggons, weighing at times, with their horses, nearly ten tons; it is in evidence, that the breadth of wheels required by various Acts of Parliament, is so easily evaded, that it affords no protection to the road; there appears to the Committee no fair reason to suppose, that steam-carriages, approaching even to this weight, will be used on any turnpike-road, at least for a very considerable period, during which the increase of weight will be gradual, and will give ample warning to the Legislature when it should interfere.

"To charge a toll according to the number of passengers conveyed, is scarcely less objectionable. If a fluctuating toll be intended, it would be as inadmissible as to propose a similar mode of charging for fast coaches, and would be open to all the cavil and interruptions to which a fluctuating toll on weight would be liable. If the toll were fixed according to the number of passengers the carriage were capable of conveying, it would imply the necessity of a licence, limiting the number of passengers, and cramping the progress of improvement of a machine, the capabilities of which can only be ascertained slowly and by continued experiment.

"It must be also recollected, that these carriages will probably have to travel for a long period without passengers, until by their punctuality and safety they shall have induced the public to venture in them. Nor is this probability weakened by the immense number of passengers who commenced using the locomotive carriages on the Manchester and Liverpool rail-way, immediately after their introduction: these engines were established among a population accustomed to machinery and steam, and therefore not entertaining the same apprehensions of its danger which will require to be surmounted elsewhere.

"The trustees of the Liverpool and Prescot road have already obtained the sanction of the Legislature to charge the monstrous toll of 1*s.* 6*d.* per 'horse-power,' as if it were a national object to prevent the possibility of such engines being used. Besides, they have supplied no standard of their own conception of horse-power. Engineers have differed very much in their estimates of this power; there is not, therefore, much probability that the opposite interests of a steam-coach proprietor and toll-collector would lead to any agreement as to the meaning of the term. But suppose the Legislature were to settle this point, and to arrange that a certain length of stroke and diameter of cylinder should represent a certain power, we still fail to ascertain that which alone it is essential to know; viz. the actual efficiency of the engine. Can we regulate the density of steam at which an engine of a given size should be worked? To be effectual, it would be also necessary to ascertain the quantity of water consumed, and even this check would be inadequate with an engine on Mr. Trevithick's principle. If the toll be left as at present on 'horse-power,' it would be the obvious interest of the proprietor to work with the smallest nominal power, but to increase as much as possible the force of his steam, thereby increasing the probability of explosion.

"Some trustees have placed the toll upon the number of wheels. The Committee would object to this mode of charge, if only, because it interferes between the rival modes of steam travelling, and gives a bounty in favour of that, in which the engine is placed on the same carriage with the passengers. The opposite plan of separating the engine from the carriage is that which probably the public will prefer, until the safety of the mode of conveyance shall have been fully ascertained.

"There is still a more serious objection to this mode of charge, it tends to discourage the use of separate carriages; although it must be evident, that if a certain weight be carried, it will be much less injurious to the road when divided over eight wheels, than when carried on four only. On this point the Committee must again refer to Mr. M'Neil's evidence. They cannot, therefore, recommend the House to adopt a scale of toll which shall increase in inverse proportion to the injury done to the road. It will be seen in Mr. M'Adam's evidence, that the toll on steam-coaches, imposed by the Metropolitan Roads Act, is liable to this objection.

"Some of the local Acts have placed an unvarying toll on steam-carriages. This, if moderate, would be unobjectionable; but the Committee could not propose any sum which would adapt itself to the necessary varieties of expense in keeping up different roads, by which the tolls on common carriages have been regulated. A fixed toll has, too, this disadvantage, that light experimental carriages, or such as are built solely for speed, would be liable to the same toll, as steam-carriages heavily laden.

"The Committee feel that, however strong their conviction may be of the comparatively small injury, which properly constructed steam-carriages will do to the roads, yet this conviction is founded more on theory, and perhaps what may be considered as interested evidence, than practical experience; they would therefore recommend, that the House should not make, at present, any permanent regulations in favour of steam. The experience which will be gained in a very few years, will enable the Legislature to form a more correct judgment of the effect of steam-carriages on roads, than can be now made. They therefore recommend that the *tolls* imposed on steam-carriages by local Acts, where they shall be unfavourable to steam, shall be suspended during *three years;* and that, in lieu thereof, the trustees shall be permitted to charge toll according to the rate to which the Committee have agreed.

"The House will have perceived, in the former part of this report, that there are two modes of applying steam in lieu of horses in draught: one, where the engine and passengers are on the same carriage; the other where the engine is placed on separate wheels, and is merely used to propel or draw the carriage. Although the difference of weight may be in favour of the former mode, yet, as on the latter it is divided over eight wheels, instead of four, its small excess cannot justify a larger toll being imposed, as it will be found much less injurious to the roads. The Committee, therefore, recommend, that in charging toll, the engine carriage and carriage drawn shall be considered but as one.

"As it is the opinion of all the engineers examined, that the use of narrow wheels has been the great cause of the wear of roads, and that cylindrical wheels, of a certain width of tire, are not only the least injurious, but that, in some states of the road, they may be even beneficial, the Committee recommend, that the wheels of the engine carriage should be required to be cylindrical, and of not less than 3½ inches width of tire. No proprietor of steam-carriages has expressed the slightest fear of any inconvenience or loss from the use of such wheels. Beyond this, the Committtee would not recommend interference with the breadth of tire, or form of wheels; it should be left to the proprietors freely to select the breadth of tire they shall find most convenient, in proportion to the weight carried.

"The Committee have divided steam-carriages (intended for passengers) into two classes, to be subject to different rates of toll. The first, where the carriage is not plying for hire, or where, if plying for hire, it shall not be calculated for, or carry at any time, more than six passengers; the original cost of such machines, and the expense of working them, will sufficiently protect the roads from any great number of merely experimental carriages; and for the same reason they will not be of a weight or size likely to be injurious. A steam-carriage only calculated to convey six passengers will be solely used where great speed is required, and will be so light as to cause very little wear of the road, probably much less than many carriages drawn by the number of horses which the Committee recommend as the standard of charge for this class. The toll, therefore, proposed to be placed on this class of steam-carriages is that, which (on the several roads, where they may be used) is charged on a carriage drawn by two horses.

"In the second class they have placed all other steam-carriages, except those travelling at slow rates, for goods only; carriages of this class should pay the same toll as may be charged on a coach drawn by four horses. This may at first appear unjust from the supposed power of steam to draw almost unlimited weight. The Committee have already enumerated the difficulties hitherto encountered in attempting to propel very heavy loads on turnpike roads. They are such as to discourage the expectation, that, within any short period of time, the system will have been so perfected as to give rise to inconvenience from this source; should any hereafter be found, it will then be sufficient to remedy the defect. Until a due proportion of the parts of the machinery shall have been ascertained, the makers of these carriages will vary but cautiously from the models at present in use; their object will be, for some time, the perfecting of them, rather than the uncertain experiment of increasing their size.

"The Committee do not anticipate, that, for a considerable period, steam will be used as a propelling power on common roads for heavy waggons. It appears to have been the general opinion of the witnesses, that in proportion as the velocity of travelling by steam on common roads is diminished, the advantages of steam over horse-power are lost. The efficiency of horses in draught is rapidly diminished as their speed is increased; while, on the contrary, the weight, which could be carried or propelled, at any great velocity, by steam, could not be more cheaply conveyed, were the speed decreased to that of the slowest waggon.

"As speed, therefore, is the cause of greatly increased expense where horses are used, while with steam it is comparatively unimportant, it is probable that the latter will be chiefly resorted to when rapidity of conveyance is required. Mr. Gurney considers, that under four miles per hour, horses can be used in draught more economically than steam. Should it, however, be deemed profitable to convey heavy goods by steam-carriages, the Committee recommend that there should be as little interference as possible with the number of carts employed; as the effect on the surface of roads would be infinitely more injurious if heavy loads were placed on a single cart, than if the same weight were divided over several. The Committee recommend, that where carriages, containing heavy goods alone, are propelled by steam, the weight of the load should be charged, without reference to the number of carts on which it may be carried.

"As a horse is able to draw from 20 to 40 cwt. on common roads, they propose that each 20 cwt. of load conveyed in, or drawn by, a steam-carriage, should be chargeable at the same rate of toll as one horse drawing a cart.

"A charge on weight is not so objectionable where goods are conveyed at a slow rate, as when speed is alone required.

"In conclusion, the Committee submit the following summary of the evidence, given by the several witnesses, as to the progress made in the application of steam to the purposes of draught on common roads.

" Sufficient evidence has been adduced to convince your Committee,—

" 1.—That carriages can be propelled by steam on common roads at an average rate of ten miles per hour.

" 2.—That at this rate they have conveyed upwards of fourteen passengers.

" 3.—That their weight, including engine, fuel, water, and attendants, may be under three tons.

" 4.—That they can ascend and descend hills of considerable inclination with facility and safety.

" 5.—That they are perfectly safe for passengers.

" 6.—That they are not (or need not be, if properly constructed) nuisances to the public.

" 7.—That they will become a speedier and cheaper mode of conveyance than carriages drawn by horses.

" 8.—That, as they admit of greater breadth of tire than other carriages, and as the roads are not acted on so injuriously as by the feet of horses in common draught, such carriages will cause less wear of roads than coaches drawn by horses.

" 9.—That rates of toll have been imposed on steam-carriages, which would prohibit their being used on several lines of road, were such charges permitted to remain unaltered."

Such then, from the clearest evidence, are the important results which elemental power, properly economised, may be brought to effect : and we confidently hope that the reader who has followed us thus far in our details, will cordially join with us in thinking that the only question that remains behind, is, how is this mighty national benefit to be brought about? Unhappily,—or perhaps happily we should say—for how often is partial evil universal good,—the state of affairs is such at the present moment as to make this a question of infinitely easier solution than it may at first sight appear. What at a more prosperous period, would have been left to be slowly carried into operation by individual philanthropists, or the combined energies of a few patriotic projectors, the pressure of the times under which we write, will force, and that speedily, to be taken up as a Government measure. Oppressed with taxes and national debt—with an increasing pauperism, and decreasing employment, we are just verging upon that crisis in our affairs, when the fortunes of all other states similarly circumstanced have irretrievably declined, and in which it becomes a matter of imperative interest and concern that the whole of the upper classes of society should combine to direct their wealth, activity, and intelligence, to the adoption of measures which, judiciously devised and vigorously executed, shall create a new impulse and tone under the ribs of death of the operative classes of society. Skill and enterprise can never long enable a country to maintain competition with younger rivals, when the rate of profit becomes reduced so low as to tempt the capitalist to seek a more lucrative investment in newer lands: and long before this Great Britain would have sunk from her proud position at the head of nations, had not continuous gigantic strides been made in manufacturing and commercial knowledge—had not every day developed new inventions and fresh resources to multiply her wealth, and extend her capabilities; but all this is not sufficient; the evil has been grappled with, not exterminated; and the project which can alone consolidate our greatness, renew our body politic, and sustain us in the energies and vigour of a wholesome existence, still lies behind. Now it unclogs the subject of a vast weight of insuperable difficulty to consider, that the want of *method* is our bane, and not the want of *means*. That ignorance has matured the distress into which the country is unnecessarily precipitated; and that knowledge, judiciously directed, can yet dissipate it, and give it to the winds. The aggregate wealth of this great country remains unparalleled, and is amply sufficient to meet and remedy the exigences of our case. We are not called upon to embark in a Utopian scheme to procure the *means*—that might baffle us—and afterwards to devise the *mode*. The former, amply provided, we have only to relieve from the immethod and fatuity of its present appropriation, and we have made to our hand what will render the completion of the latter a project of comparative facility and ease. The scheme is not a brilliant chimera irreducible to practice, but is laid up and embraced in this simple axiomatic proposition, which opposition may challenge—but we defy to overthrow:—*That the* FOOD *of the country, properly converted, is fully sufficient to extinguish pauperism;—and that the fund by which that pauperism is at* *present upheld, encouraged, and fostered, can furnish the* MEANS *by which the conversion in question may effectually be realized.*

The poor-rates levied in England and Wales for the year ended March, 1831, amounted to the enormous sum of 8,279,217*l.* 14*s.* sterling; of which 6,798,888*l.* 18*s.* was disbursed for the relief of the poor! Here then is an annual (and increasing) cancerous expenditure of upwards of eight millions of unproductive capital, eating into the vitals of the community, and creating and perpetuating the very evil which it is intended to remedy. Now such a portion of this sum as is at present applied to the purpose of supporting able-bodied paupers, is amply sufficient in itself, during the course of a few years, if it be so directed, to carry into operation this great national measure, which will give bread in the mean time to the unemployed class in question; and realise, as already shown, an effect which in a great measure will annihilate pauperism and redundancy altogether.

But though in this amount of 6,798,888*l.* 18*s.* we have a disposable sum, which the rate-payers of England will find it to be their interest, as it is their duty, to convert to the purpose suggested; the benefits which will accrue from its adoption, to all classes of society, is one that entitles it to the pecuniary support, and the political assistance, not merely of every individual, but also of Government itself. If Mr. Wilmot Horton's emigration remedy, which required a sum of 75*l.* per family, or 15*l.* per head, and a period of eight years to occasion a drainage of *one million* of our surplus population, was recommended to the consideration of Parliament, by "*evidence which rendered its adoption expedient;*"—if it, at an expense of *fifteen millions sterling,* and at a period of time sufficient to reproduce with its lapse an *increase* of population equal in amount to the number expatriated, was, so lately as 1830, by a Committee of the "collective wisdom" of the State, styled a "benefit of almost inconceivable degree," what shall we style that project which can, by a simple and practical application of mechanic power, create a quantity of food equal to a consumption *four-fifths* greater than our present exigences require, and which too can be operated by a means which will *extinguish the very cause* which has hitherto saturated the country with indigence and unemployment?

We are aware, from the latter-mentioned distinguished and philanthropic economist laying it down as an axiom, that the term *redundancy of population*, applies " strictly, guardedly, and uniformly, to a population *redundant as labourers*, and who, having no opportunity of exchanging labour for food, are not in a situation to purchase food," that it will afford ground for the objection, that *pauperism* results from want of employment, not from deficiency, or dearness, of provisions. With all deference however we submit, that there is in reality, at best, but a difference in terms here, not in things, for they resolve into each other. In this country, of all others on the globe, it may be most truly affirmed, that man earns his bread by the sweat of his brow, and that in sorrow he eats of it all the days of his existence. There is no proportion whatever between the labour done, and the remuneration that requites it. Ten hours of continuous tear and wear of muscular exertion daily, for six days in succession, is, at present, from the high price of food, barely sufficient to earn as much wages as will keep soul and body together. There is a crying grievance in this system; but what is more to our point, there is a fatal evil in it also. However profitable a cheap rate of wages may appear to the employer, it is in reality accompanied with drawbacks which render it in the main infinitely disadvantageous and undesirable. It is, in fact, the parent of the poor-rates—that evil which now costs us eight millions sterling, and which, growing annually, if not checked, will piece-meal convert England into one vast poor-house. Now under a system, which we will say will reduce the price of provisions one-half, *i. e.* which will enable a labourer, for three days' wages, to procure as much food as he now does for six—you in effect create employment for *double* the labouring poor in the country. And how do we arrive at such a conclusion? Why just from the simple fact, that man labours from compulsion, not willingly. Remove the dire necessity of the case—make his daily bread not the result of his daily exertion, and you subdivide labour in such a way, that you generalize its product, as well as equalize it. The ditch and the road, the spade and the pick-axe, are not so inviting that man will cling to them, even for love of the payment, except when the alternative is abject beggary and starvation.

It will be opposed to this conclusion, that cheapness of food, under the system we advocate, will be accompanied by a proportionate reduction of wages, which will leave the labourer just as unprovided for, as poor and needy, as at the present moment. There is something so plausible in this objection, that we should be apt to give up our position as untenable, did we not, under the operation of the new *regime*, contemplate a *change in agriculture*, which will make cheapness of food, and a generalization of capital, terms synonymous.

We have just shown how, under this measure, a *subdivision of labour* will drain off, in a great measure, our redundant unemployed: we have now to show how another result, a *subdivision of land*, will be a means of growing wealth to the community. We think it will readily be granted, that the undue preponderance of the operative over the agricultural classes of society is the bane of the country; because it produces a fictitious and dependent state of livelihood, which is continually exposed to casualties and fluctuations. Now this state has been matured by the high price of food, which has had the effect of making *large farm-monopolies* abound, greatly to the prejudice and impoverishment of the multitudes, who have in consequence either been thrown out of employment altogether, or else into employment which has terminated in indigence. We should be sorry to advocate such a division of land as would in any way approach to an equalization of it. We know too well the evil of the potato-garden system of Ireland, and the misery arising from the same, ever to wish an approximation to it in England; but we contend that an evil, similar in kind, and not much less in degree, arises out of our surplus of mechanics and traders; and we hold, that any measure that will let off this gorged and stagnant body, and direct it into a channel independent of the rise and fall of foreign markets, will convert it from its present putrescent and worse than useless state, into a current fertilizing top-dressing for our national growth in progressive and stable prosperity; and will be beneficial just in so far as it will convert starving manufacturers into prosperous consumers, and make a benefit of that which at present is pregnant with nothing but wretchedness and disadvantage. Now that this will flow out of this measure, we deduce thus:—cheap food will shortly annihilate overgrown farms; for the causes being removed which have hitherto made these objects of speculation and investment of large capital, proprietors will find the advantage of appropriating their estates in smaller allotments; and thus furnish a vast and most desirable outlet for multitudes who are at present otherwise unprofitably engaged. That proprietors will consult their own truest interest, as well as their country's, by doing so, we should have been content to have left as a self-evident statement. The following extract however, from a letter, signed "A Proprietor," and dated Brighton, 14th February last—published in the Morning Herald —is so affirmative of our view, that both on that account, and to relieve ourselves of the charge of dogmatizing, we take the liberty to transcribe it.

"Labourers, when cherished by landlords, form, like the basis of the pyramid of Egypt, the powerful basis of national wealth and power. Suppose one-fifth, or one-third of every landed estate throughout the kingdom was allotted to this class of society, some millions of poor-rates would be saved annually—the aggregate rental much increased—a nation of customers for the revenue created—the population become vastly more numerous—and instead of an oppressed people, ripe for rebellion, an opulent and happy nation; the poor-rates might then be a dead letter, as in Scotland.

"In England, pauperism, which for centuries has been and is still increasing, threatens to involve the country, like an Etnæan stream of lava, in desolation and destruction. The evil has baffled our ablest statesmen. How, then, can the stream of lava be stopped, and be converted into a fertilizing stream, like the Nile of Old Egypt? There is no axiom more self-evident than this: 'If you make men rich, they will no longer be poor.' If all industrious able-bodied labourers were allowed to rent comfortable cottages, with three or four acres of land,—or, if poor land, of eight or ten acres, attached,—they could afford to pay a much higher rent than the farmer; and, instead of being, as paupers, a nuisance and an expense, would shortly become our stablest and most profitable tenants. I speak from thirty years' experience. One case is as good as a hundred:—a young sturdy pauper applied to me for a house and food; I let him four acres of land at twice the rent a farmer would have paid me. To the hour of his death he was one of my best tenants; many of my most respectable farmers have failed; but my cottager stood like the oak. If I had spurned him, he must have had a cottage rent-free; and, allowing 8*s.* weekly for himself and family from the poor-rates, it would have been an annual encumbrance of expense of 20*l.* On the contrary, I prevented this loss, and gained a valuable tenant, who paid me a profit of cent. per cent. more than my farmers."

The remark is almost a superfluous one, that a measure which will benefit the poor of our community, will benefit the rich also. If it be true that the wealth of the upper classes seek down, diffusing comfort and prosperity among the lower classes; so is it equally true, that the distress of the lower orders seek up, communicating the baneful effects of embarrassment and retrenchment throughout all the ramifications of upper society. The sanity of the body-politic, like that of the body-physical, can only be maintained by the whole members' economising for each other's welfare. "The mighty Sovereign Ruler of the universe has most wisely ordained," remarks Sir Thomas Baring, in his speech at the late meeting of the "Labourer's Friend Society,"—"that no individual, let his station or circumstances be what they may, shall be independent of his fellow-man. The poor is dependent for employment on the rich; but the rich is equally dependent on the poor for the fruits of his labour, which contribute to his happiness. The great, the good, and pious Lord Chief-Justice Hale has well said, that the wise man is but a steward of his wisdom, and the rich man a steward of his riches; and that the best account each will be able to give of his stewardship will be, that he has applied his wisdom, or riches, to the reformation or benefit of his fellow-men." Nor can we resist adding what the noble chairman of the said meeting (Lord Morpeth) says so judiciously to the same purpose:—"He considered that they would not be acting out of their place, nor transgressing the course of nature, or the will of Providence, by a patient and steady endeavour to give to the labouring portion of the community the means of bettering their condition, with opportunities for acquiring the wish for still further progress, and an interest in exertion, a taste for comfort, a sense of independence, some foresight for the future, some leisure for the concern of an immortal soul. He considered that the same means which are effectual for the well-being of the industrious poor, would also, in the long run, tend to augment the resources of their superiors. He did not wish to give to benevolence the suspicion of being swayed by interested motives, except so far as that beautiful law of reaction goes, which seems to run through the whole scheme of Providence—'blessing him that gives, and him that takes.' Danger can only be encountered by a performance of duty; and in promoting the physical comfort, developing the moral and intellectual qualities, engaging the affections, and warming the piety of the largest class of the community, we shall adopt the likeliest course to augment the national prosperity, and to call down the blessings of Providence."

Nor if arguments such as these be potent to awake and direct the attention of the interested part of our readers, is it possible, do we conceive, to bring forward, to enlist the Christian philanthropist in the cause, an appeal equally splendid in conception, —as affecting in detail—or more powerful to arouse and direct our moral sympathies, than what follows from the pen of the eloquent Professor of Moral Philosophy in the University of King James[1]. Speaking of the operative classes of society, and the privations of their condition, he proceeds to remark: "I ask you, if it be not the most melancholy parts of all the speculation that is suggested to the moral inquirer by the condition of man, to observe what a wild and dense gloom is cast over the souls of this class by this severe necessity of continued labour, which is, nevertheless, the great and constant source of the improvement of their condition? It is not suffering alone—that they may be inured to bear; but it is the darkness of the understanding, and it is the callousness of the heart, which comes on under the operation of the toil to which this human being, whose nature it is our province to explain, must be subjected; it is all that which is most miserable for us to behold. For if men, born with the same spirit as ourselves, are yet denied the common privileges of that spirit, they seem to bring certain faculties into the world that cannot be unfolded—certain powers of affection and desire which, we might be inclined to say, the lot of their birth will pervert and degrade. There is a humiliation laid on human nature in the doom which appears thus to rest on a great portion of the species, which, while it requires our most considerate compassion for those who are so depressed, compels us to humble ourselves under a sense of our own participation in the mysterious nature from which it all flows. Therefore, in estimating the worth or the virtue of our fellow-men, whom Providence has placed in a lot which yields to them the means, and little more than the means, of supporting life in themselves, and those born of them, what moral inquirer would ever, for a moment, forget, how intimate is the necessary union between the wants of the body and the thoughts of the soul? Let us remember, that over the great proportion of our humanity the soul is in a constant struggle for its independence with the necessities of that nature in which we know it to have been enveloped. It has to support itself against irritating or maddening thoughts inspired by weariness, lassitude, and want, or the fear of want. It is chained down to the earth by the influence of one great and constant occupation—that of providing the means of its mortal existence. When it shows itself shocked or agitated, or overcome in the struggle, what ought to be the thoughts and feelings in the consideration of the wisdom of poor humanity?

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[1] Extract from the Introductory Lecture delivered in the University of Edinburgh, on Tuesday, Nov. 8th, 1831, by Professor Wilson.

"When, on the other hand, you see nature preserving itself more boldly amidst the perpetual threatenings, or unceasing assaults, of those evils from which it never can make its escape, and though pressed by its own many wants, forgetting them all in that love which ministers to the wants of others: when you see the brow wrinkled and drenched by incessant toil, the body bowed down to the dust, and the whole frame in which the immortal spirit abides marred (but surely not dishonoured) by its slavery; and then, when, in the midst of all that depression and oppression, you see man still seeking and still finding joy, delight, and happiness, in all the finer affections and desires of his spiritual being, giving to the lips of those he loves that scanty morsel earned by his own hungry and thirsty toil—purchasing by sweat, sickness, and fever, the useful education, and religious instruction, of the young creatures who delight the heart of him who is striving for their sakes—resting with gratitude on that day which is like a fountain in the midst of the thirsty wilderness to his exhausted and wearied frame—and preserving a high sense of his own immortality amongst all the toils and struggles that would fain chain him to the dust; when, I say, you see all this, and think of all this, you will discover how rich may be the very poorest of the poor, and you will learn to respect the moral being of man in these its triumphs over the power of his physical nature. But you do not learn from this to doubt or to deny the wisdom of the Creator. You do not learn from all these struggles, and all these defeats, and all these most glorious victories, and all these triumphs, that God sent his creatures into this state of existence to starve, or that the air, the earth, and the waters, have not wherewithal to fill the mouths that gape for food. Nor will you ever learn that want is a crime, or that poverty is a sin, or that they who would toil but cannot, or that they who would toil but have not work, are intruders at Nature's table, and must be driven to famine, starvation, and death."

Sed jam satis! with the remarks of these enlightened and patriotic men, as corroborative of our views, we have now to close this volume: which we do by expressing an earnest and fervent wish, that the conversion of steam to economic purposes, as a scheme of interest, of duty, of humanity, and of morality, will be taken up, and that immediately, by all classes of society, with the spirit due to its vast importance. The public mind opens, we are aware, but slowly to the advantages to result from the adoption of any novel project; and when the fetters, not merely of ignorance but also of selfishism, are to be broken, it may indeed be said, hic labor, hoc opus est! We are, nevertheless, not unsanguine that the wonderful realities of steam, as at present exemplified, will not be impotent in relieving the public mind from scepticism as to its almost indefinite utility when directed to any specific purpose. The modification in question is one whose practicability and utility alike lie upon the surface: whose adoption can be attended by little partial evil, and be productive of great universal good. Our treatise has not been upon the science of political economy, falsely so called, involving contradiction, or devolving speculation—but explanatory of a master-movement in mechanics, which will operate throughout every department and ramification of our distressed commercial, agricultural, operative, and social community, the most important benefits. In laying down this proposition, which it has been the object of our work to demonstrate, we bring our subject to its close. And happy shall we be if we have discharged our task in such a manner as shall introduce it to the common sense of the British people. The subject-matter is one of too vast importance in itself to require an elaborate apology on our part for the shallow manner in which we have treated it. The practical man who has waded through the facts which we have detailed, will not have done so without allowing that *nous avez raison* for the conclusions that we have arrived at; nor will he shut his eyes upon the consideration, that a subject such as this, involving so many occult as well as apparent advantages, which would have appeared important even in the hands of a child, would have attained to a gigantic magnitude if brought out in the length and breadth of all its varied practical applications. We flatter ourselves, that what we have advanced will associate with us, in the cause of forwarding the adoption of this great measure, not a few of those eminent financiers, whose enlarged knowledge will correct our inadvertencies, supply our deficiencies, and swell out the meagre outline of its estimated advantages to their full extent: as well as engage the press, and the pen of the many philanthropists whose breasts will dilate in gladness over the beneficial effects of this noble project. Should our hopes fail us here, we will at least rest satisfied,——beholding in perspective, as the only possible measure which can save the empire from destruction, the certain eventual enlarged application of that beneficent agent which now makes the stately vessel walk the water as a thing of life,—which *may* direct the gladsome plough over the mountain's side,—and which *shall* assuredly, and that at no distant date, roll the tide of human life, and the produce of human industry, through all the once more prosperous glens and dales of renovated England,——that we at least have done somewhat to hasten that day, by endeavouring to beget and to arouse a spirit of examination and experiment respecting the practical adoption of a project, than which one equally splendid, and as universally advantageous in all its results, never yet engaged the attention, nor claimed the patronage, of the British people.

APPENDIX.

APPENDIX (A.)

TABLE showing the great and rapid decrease of the effective power of a horse; from which calculation the great advantage of steam, at high speeds, may be ascertained.

A horse travelling 1 mile per hour draws 196lbs. actual pull on the collar.

2	169
3	144
4	121
5	100
6	81
7	64
8	49
9	36
10	25
11	10
12	9
13	4
14	1
15	nothing.

APPENDIX (B.)

THE following was the annual expense of horse coaches on the turnpike-road betwixt Manchester and Liverpool, previous to the opening of the railway: taken from the petition to parliament of the coach-masters on that road.

				£.	s.	d.
Duty upon 33 coaches				8455	16	8
Assessed Taxes on servants				261	0	0
Mileage for 26 coaches to Manchester, at 13*l.* 4s. per day	£4818	0	0			
Mileage for coaches to Bolton, at 1*l.* 15s.	638	15	0			
Carried over	£5456	15	0	£8716	16	8

Brought forward	£5456 15 0	£8716 16 8	
Mileage for coaches to Wigan at 4s. 8d.	267 13 4		
Mileage for coaches to St. Helens	54 15 0		
		£5779 3 4	
			14,496 0 0
Tolls for 33 coaches, at 18*l.* 10s.			8,005 13 4
			£22,501 13 4
Harness for 709 horses, at 4*l.* each		2,836 0 0	
Iron and labour, blacksmith's, 709 horses, at 3*l.*		2,127 0 0	
87 hostlers, at 1*l.* per week		4,524 0 0	
Rent of stables and coach-offices		1,418 0 0	
Consumption of horses 15*l.* each, to be renewed every three years		3,545 0 0	
Hay and corn for 709, at 15s. per week		27,651 0 0	
			42,101 0 0
			£64,602 13 4

APPENDIX (C.)

Extracts from Seventh Report of the Holyhead Road Commissioners; showing the number of lbs. required to draw a Waggon of the weight of 21 *cwt.* 8 *lbs., at the rate of* 2½ *Miles per Hour.*

1. PARTS on which the Experiments were tried.	2. Number of Observations.	3. Rate of Inclination.	4. Actual Draught in lbs., or proportional Number of Horses required on each Station.	5. Correction for the Rate of Inclination.	6. Draught reduced, or the proportional Number of Horses that would be required if the Road was horizontal.	7. OBSERVATIONS. All the Experiments were made in the middle of the month of March, 1830, during dry weather.
No. 1.						
PICCADILLY PAVEMENT.						
From Stratton Street to Devonshire House	15	rise, 1 in 114	60½	20½	40	Excellent, smooth, well-laid pavement.
Devonshire House to Dover Street	14	rise, 1 — 156	48¼	15¼	33	Ditto, ditto.
Dover Street to James's Street	13	fall, 1 — 429	42¼	5¾	48	Pavement uneven, and worked into holes; the top of the stones a good deal rounded, and the joints opened.
St. James Street to Bond Street	8	rise, 1 — 245	54	9	45	
Bond Street to Burlington Arcade	11	fall, 1 — 286	40	8¼	48¼	
Burlington Arcade to Albany Court	20	horizontal	41¾	..	41¾	

APPENDIX (C.) *continued.*

1.	2.	3.	4.	5.	6.	7.
No. 2. **Archway Road.**						
Between toll-bar and new house on the right..........	32	rise, 1 in 23	173	102½	70½	This road lately repaired, by putting on a cemented foundation, and covering the fifteen middle feet with broken Guernsey granite, six inches in thickness.
Between new house and Depôt No. 1.......	13	rise, 1 — 23	163	102½	60½	
Between Depôt No. 1. and Archway	64	rise, 1 — 22	171	108	63	
Between Archway and lamp No. 11	31	rise, 1 — 49	115	48	67	
Between 11th and 12th lamp-posts	13	rise, 1 — 229	78	10¼	67¾	
Between 12th and 13th lamp-posts	12	horizontal	47	..	47	
Between 13th and 15th lamp-posts	26	fall, 1 — 382	46	6¼	52¼	
Between 19th and 21st lamp-posts	35	rise, 1 — 27	151	87	64	
Between 21st and 22d lamp-posts	22	rise, 1 — 27	152	87	65	The surface not perfectly consolidated, and shaded with trees.
Between 22d lamp-post and M'Pherson's...	16	rise, 1 — 3437	59	−½	58½	
Between Wellington Inn and Whetstone Road	20	horizontal	44	..	44	On this portion Hartshill was used instead of granite.
No. 3. **Hockliffe and Stratford Trust.**						
Near Fountain Inn, Shenley...........	49	horizontal	97	..	97	12 inches of limestone; low fences.
Near Talbot Inn, north of Shenley	36	rise, 1 — 20½	232	115	117	Do., good foundation, firm and dry, not worked in.
Flat, north side of Shenley..............	34	fall, 1 — 119	93	19¾	112¾	12 inches limestone; plantation south side.
Ditto, near Speckland Hollow..........	77	horizontal	120	..	120	11 inches pebble and limestone; plantation south side.
Crown Hill..........	38	rise, 1 — 45	128	52½	75½	Embankment; paved foundation, covered with 10 inches of broken limestone.
Ditto, near summit...	26	rise, 1 — 27	136	87	49	
Between Crown Hill and the toll-bar	56	rise, 1 — 66	115	35¾	79¼	12 inches limestone; no sub-pavement.
Flat between Two-mile Ash and Stony Stratford	68	rise, 1 — 3437	60	1	59	18 inches limestone; low fences, no trees.
Near same place, tried back.............	58	fall, 1 — 3437	57	1	58	Ditto, ditto.

APPENDIX (C.) *continued.*

1.	2.	3.	4.	5.	6.	7.
No. 4.						
Stratford and Dunchurch Trust.						
Flat between 65th mile-stone and brick-house	23	rise, 1 — 20	270.	118	152	6 inches limestone; low fences each side; trees and high bank on west.
Between brick-house and road to Northampton	7	rise, 1 — 21	292	112	180	5½ inches limestone; high hedges, and bank on south-west.
Over small embankment above brick-house ..	22	rise, 1 — 22¾	343	103	240	6 inches limestone; high hedges; new stone, on a week.
Between sand-pits and road to Stowe......	23	rise, 1 — 39	128	60½	67½	6 inches limestone; open and low fences.
Between road to Stowe and the Angel Inn ..	37	rise, 1 — 71½	95	33	62	5 inches limestone; open wide space between; low fences.
Between hollow and 66th mile-stone	70	rise, 1 — 31	130	76	54	3½ inches of Hartshill, and 2 inches of limestone, on pitching.
Between 66th mile-stone and summit of hill ..	80	rise, 1 — 26	145	91	54	3 inches ditto, ditto, over embankment.
Rising next hill	60	rise, 1 — 50	90	47	43	5 inches ditto, ditto, through cutting.

Extract from Mr. Telford's Report on the state of the Holyhead and Liverpool Roads.

Being authorized by the commissioners to have the machine invented by my assistant, Mr. M'Neil, (for measuring the force of traction, or the labour of horses in drawing carriages) completed, and also to have the several districts of the Holyhead road in England tried by it; Mr. M'Neil has done so, and prepared a statement, showing the results of the trials between London and Shrewsbury, a distance of 153¼ miles.

The general results of these experiments[1] on different sorts of roads, are as follow:—

1.—On well-made pavement, the draught is....	33 lbs.
2.—On a broken stone surface on old flint road,	65 —
3.—On a gravel road	147 —
4.—On a broken stone road, upon a rough pavement foundation......................	46
5.—On a broken stone surface upon a bottoming of concrete, formed of Parker's cement and gravel	46 —

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[1] In making these experiments, a waggon weighing about 21 cwt. was used.

"The general results of experiments made with a stage-coach [1], on the same piece of road, on different inclinations and at different rates of velocity, are given, from which

The following Statement has been calculated:—

Rate of Inclination.	Rates of Travelling.	Force required.
1 in 20	6 miles per hour.	268 lbs.
1 — 26	6 —	213 —
1 — 30	6 —	165 —
1 — 40	6 —	160 —
1 — 600	6 —	111 —
1 — 20	8 —	296 —
1 — 26	8 —	219 —
1 — 30	8 —	196 —
1 — 40	8 —	166 —
1 — 600	8 —	120 —
1 — 20	10 —	318 —
1 — 26	10 —	225 —
1 — 30	10 —	200 —
1 — 40	10 —	172 —
1 — 600	10 —	128 —

"Having the results of these accurate trials to refer to, leaves it no longer a matter of conjecture in what manner a road should be made, to accomplish most effectually the main object, that is, diminishing to the greatest possible degree, the labour of horses in draught.

"Although the observations of scientific persons have led to nearly similar conclusions, others have been in the habit of laying down rules for road-making at variance with all the established laws of motion; it is satisfactory to be able to produce a positive proof by actual experiment, of their opinions being wholly erroneous.

"In this view, I consider Mr. M'Neil's invention for practical purposes on a large scale, one of the most valuable that has been lately given to the public."

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[1] Weight of coach, exclusive of seven passengers, 18 cwt.

APPENDIX (D.)

Answers to Queries submitted by the Committee to Mr. John M'Neil.

"QUERY 1.—'What is the greatest weight, in proportion to its own weight, which any locomotive steam-engine has been found capable of drawing upon a rail-road, and at what velocity?'

"In the first edition of Mr. Nicholas Wood's treatise on rail-roads, published in 1825, he states that a locomotive engine, weighing 6½ tons, and containing one ton of water, equal to 7½ tons, dragged twelve loaded carriages, each weighing 9,408 lbs., up a plane ascending 134 inches in 1,164 feet, and also the conveying carriage, weighing 1¼ tons, the wheels not slipping, the rails dry.

"He also gives the following experiments made on the Killingworth railroad: The length of plane was 2,260 yards, with an ascent in one direction of 6 feet 5 inches, not uniform, varying from a dead level, or slightly undulating, to an ascent in one place of 1 in 330. Edge-rail, 2¼ inches broad on the surface; carriages all the same construction, weighing 81¼ cwt. each, wheels 34 inches diameter, axles 2¾ inches diameter.

Experiment 29.

"Wheels, three feet; nine carriages, weighing 731¼ cwt., were drawn up the plane fourteen times in 317 minutes, and fourteen times down the plane in 258 minutes; distance traversed, 36 miles in 9 hours, 35 minutes; coals consumed, 2,534 lbs.; water, 890 gallons.

Experiment 30.

"Wheels, four feet; nine carriages, weighing 731¼ cwt., were drawn up the same plane nineteen times in 302 minutes, and nineteen times down the plane in 265 minutes; distance traversed, 48·8 miles in 9 hours, 27 minutes: coals consumed, 2,534 lbs.; water, 854 gallons.

Experiment 31.

"Wheels, four feet; twelve carriages, weighing 975 cwt., were drawn up the plane nine times in 155 minutes, and nine times down in 133 minutes. Distance traversed, 23 miles in 4 hours, 48 minutes; coals consumed, 1,546 lbs.; water, 452 gallons.

Experiment 32. (With a different Locomotive Engine.)

"Wheels, three feet; nine carriages, weighing 731¼ cwt., were drawn up the same plane ten times in 212 minutes, and ten times down in 180 minutes. Distance, 26 miles; time, 6 hours, 32 minutes; coals consumed, 1,487 lbs.; water, 490 gallons.

Experiment 33.

"Wheels, four feet; twelve carriages, weighing 975 cwt., were drawn up the plane five times in 45 minutes, 48 seconds, and five times down, in 40 minutes, 26 seconds. Distance each journey, 2,002 yards. Total 11·375 miles; distance passed over in the above time 1,663 yards each journey, or 9·45 miles; time, 1 hour, 26 minutes, 14 seconds; coals consumed, 587 lbs.; water 200 gallons.

"In this experiment the engine was allowed to traverse a given space, to put the train of carriages into their proper velocity before the time was noted; the time was then marked until the velocity was again checked at the farther end of the stage. This will explain the difference between the two distances stated in the experiment; the one was the whole distance from the commencement to the end of the stage; the other was that part of the stage which the engine passed over when the regular velocity was acquired, and before it was again diminished at the end of the stage, to stop the train; the time given was that which transpired while the engine was passing over that space, while the velocity was uniform, and may therefore be taken as a measure of speed.

"At page 281, Mr. Wood states, upon a rail-road, near Newcastle, a locomotive engine in fifty-four weeks conveyed 53,823 carriages of coals, each weighing 9,438 lbs., 2,541 yards, and returned with the same number of empty carriages, each weighing 3,472 lbs. This was in fifty-four successive weeks, and, in that time, exclusive of Sundays, the engine, from want of goods to convey, was at least twenty days off work; so that in 304 days the performance was 446,815 tons conveyed one mile; or 1,470 tons one mile each day on a stage only 2,541 yards. The engine had three feet wheels, which were calculated for a rate of about 4½ miles per hour.

"Mr. Rastrick, in his report to the directors of the Liverpool and Manchester rail-way, dated January, 1829, gives the following table of the absolute quantity of work done by five different locomotive engines, when reduced all to the same standard of five, eight, and ten miles per hour. The carriages proportioned to the weight of goods, in the some ratio as they were proposed for the Liverpool and Manchester Railway, and also of the work that the ten-horse engine, proposed by him and Mr. Walker, would be capable of doing.

TABLE.

ENGINES.	RAIL-ROADS.	IN SUMMER.												IN WINTER.											
		At 5 Miles per Hour.				At 8 Miles per Hour.				At 10 Miles per Hour.				At 5 Miles per Hour.				At 8 Miles per Hour.				At 10 Miles per Hour.			
		Goods.	Carriages.	Engine and Tender.	Gross Weight.	Goods.	Carriages.	Engine and Tender.	Gross Weight.	Goods.	Carriages.	Engine and Tender.	Gross Weight.	Goods.	Carriages.	Engine and Tender.	Gross Weight.	Goods.	Carriages.	Engine and Tender.	Gross Weight.	Goods.	Carriages.	Engine and Tender.	Gross Weight.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Engine on six 4 feet wheels, Hackworth	Stockton & Darlington	47¾	23¾	15	86½	26	18	15	54	18¾	9½	15	43¼	40¾	20¼	15	76	21¾	10¾	15	47½	15¼	7¾	15	38
Engine on four 4 feet wheels -	Stockton & Darlington	34⅔	17⅓	12	64	18⅔	9⅓	12	40	13⅓	6⅔	12	32	28¾	14½	12	55¼	15	7⅓	12	34⅓	10 3/10	5 3/10	12	27 6/10
Engine on four 4 feet 2 in. wheels	Killingworth Colliery	38	19	10½	67½	21	10½	10½	42	15⅝	7⅝	10½	33¾	31¼	15¾	10½	57½	17	8½	10½	36	12	6¼	10½	28¾
Engine on four 3 feet wheels -	Hetton Colliery	24¼	12	10½	46¾	12½	6¼	10½	29¼	8⅝	4⅜	10½	23½	19¾	9¾	10½	40	9¾	4¾	10½	25	6¼	3¼	10½	20
Engine on 4 wheels, rack rail -	Middleton Colliery, near Leeds -	22¼	11	6¼	39½	12¼	6¼	6¼	24¾	9	4½	6¼	19¾	19¼	9½	6¼	35	10¼	5¼	6¼	21¾	7½	3¾	6¼	17½

"The engines started for the premium of £500, on the Liverpool and Manchester Railway, in October, 1829, were, the *Rocket*, *Novelty*, and *Sans Pareil*.

	Tons.	Cwt.	Qrs.	Lbs.	
The *Rocket* weighed..............	4	5	—	—	—Full speed 30 miles in 2 h. 14 m. 8 s. equal to 13 $\frac{4}{10}$ per hour; back, 30 miles in 2 h. 6 m. 9s. equal to 14 $\frac{2}{10}$ per hour.
Tender, with water and coke	3	4	—	2	
Two carriages loaded........	9	10	3	26	
	17	—	—	—	
Sans Pareil—weight of engine....	4	15	2	—	—Full speed, 10½ miles in 50 m. 49 s. equal to 12 $\frac{4}{10}$ per hour; back, 12 miles in 40 m. 27 s. equal to 15 $\frac{5}{10}$ per hour.
Tender, with water and fuel..	3	6	3	—	
Three carriages.............	10	19	3	—	
	19	2	—	—	
Novelty—weight of engine with water in the boiler........	3	1	—	—	—Total time, 22 m. 57 s. and distance run 4½ miles.
Tank, water, and fuel........	—	16	—	14	
Two carriages...............	6	17	—	—	
	10	14	—	14	

" N.B.—The railway was level, and about two miles in length, where the experiments were made.

" Query 2.—' What may be considered as the greatest performance of locomotive carriages previous to the Manchester and Liverpool Railway being opened?'

" Mr. Wood, in 1825, states that the performance of the best locomotive engine was equal to 40 tons, conveyed at the rate of six miles an hour; and four years after (in 1829), Messrs. Rastrick and Walker have stated, that 48½ tons conveyed five miles an hour, or 19½ tons conveyed 10 miles an hour, was the greatest performance the directors of the Liverpool Railway could expect from them.

" I have seen some statements of experiments in which the effective work was greater than the above; but I am inclined to think, they could not be so well depended on as those of Messrs. Wood, Rastrick and Walker.

" Query 3.—' What has been the greatest performance of any engine since that period?'

" On the 23d of February, 1831, Mr. Robert Stephenson stated to the Society of Civil Engineers, that the Northumbrian locomotive engine, weighing 6 tons 3 cwt., drew 50 tons up the inclined plane at Rainhill, at the average rate of 7½ miles per hour: pressure of steam was 50 lbs. on the square inch. The inclination of the ground at Rainhill is 1 in 96.

" On the 1st of March, 1831, Mr. Locke stated, that 'The Samson' drew a gross weight of 151 tons in 30 waggons (the nett weight being 107 tons), the whole distance from Liverpool to Manchester, in 2 hours 34 minutes, including 13 minutes of stoppages. The diameter of the wheels was 4 feet 6 inches.

"On the 19th of April, 1831, Mr. Locke stated, that 'The Samson' drew up the inclined plane at Rainhill about 44½ tons gross of goods and waggons, at the rate of about 8 miles an hour.

"Weight of the engine was 8½ tons; weight of tender (which was full of water), 4 tons; making the total weight of goods, waggons, engine, and tender, 57 tons; and, calculating the speed of the engine 8 miles per hour, she was exerting a force equal to 39-horse power.

"He also stated, that a new engine, 'The Jupiter,' had just been started. From the 4th of March to 6th of April, she drew 226 waggons (only 10 of which were empty) and 847 coaches, a total distance of 3,426 miles. In one fortnight she made 50 journeys, equal to 1,500 miles.

"Diameter of cylinder, 11 inches; length of stroke, 16 inches; diameter of the wheels, 5 feet. Value of such an engine, 700*l.*"

THE END.

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